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India enters hypersonic club

the HSTDV is capable of powering missiles to attain six times the speed of sound and only a select few countries like the US, Russia and China have such a capability

The Defence Research and Development Organisation (DRDO) successfully flight tested the Hypersonic Technology Demonstrator Vehicle (HSTDV) – an unmanned scramjet vehicle with a capability to travel at six times the speed of sound. The HSTDV is capable of powering missiles to attain six times the speed of sound and only a select few countries like the US, Russia and China have such a capability. Let's take a look at the vehicle and the importance of the test.

Significance of the test

According to DRDO with this mission, it has demonstrated capabilities for highly complex technology that will serve as the building block for NextGen Hypersonic vehicles in partnership with industry.

- The test was conducted from Dr APJ Abdul Kalam Launch Complex at Wheeler Island, off the coast of Odisha today, the Agni missile was used. A solid rocket motor of Agni missile was used to take to an altitude of 30 kilometers where the cruise vehicle separated from the launch vehicle and the air intake opened as planned.
- The parameters of the test were monitored by multiple tracking radars, electro-optical systems and telemetry stations and a ship was also deployed in the Bay of Bengal to monitor the performance during the cruise phase of hypersonic vehicle. All the performance parameters have indicated a resounding success of the mission, officials said.
- Scientists believe that while the successful test is a major milestone, many more rounds of tests will have to be done to achieve the level of technology with countries like the US, Russia and China.

Scramjet engine

- The scramjets are a variant of a category of jet engines called the air breathing engines. The ability of engines to handle airflows of speeds in multiples of speed of sound, gives it a capability of operating at those speeds.
- Hypersonic speeds are those which are five times or more than the speed of sound. The unit tested by the DRDO can achieve up to six times the speed of sound or Mach 6, which is well over 7,000 kilometers per hour or around two kilometers per second.
- For the test on Monday, the hypersonic combustion sustained and the cruise vehicle continued on its desired flight path at a velocity of Mach 6 for a period of 20 seconds.

Technology development

- The DRDO started on the development of the engine in early 2010s. The Indian Space Research Organisation (ISRO) has also worked on the development of the technology and has



successfully tested a system in 2016. DRDO too has conducted a test of this system in June 2019.

- The special project of the DRDO consisted of contributions from its multiple facilities including the Pune headquartered Armament and Combat Engineering Cluster. According to DRD, at the hypersonic speeds, the system has to handle temperatures to the range of 2500 degrees celsius as well as the air speed, and thus development of the material is one of the main challenges.

<https://telanganatoday.com/india-enters-hypersonic-club>



Wed, 09 Sept 2020

DRDO joins the Big Boys with a hypersonic achievement | India Today Insight

The successful flight of its hypersonic rocket engine after 15 years of hard work catapults India into an exclusive club that has just three nations

By Raj Chengappa

On a bright Monday morning, Defence Research and Development Organisation (DRDO) scientists had gathered at the A.P.J. Abdul Kalam Launch complex at Wheeler Island off the Odisha coast to anxiously witness the demonstration of what is regarded as the Holy Grail of missile technology: a hypersonic cruise missile that can use atmospheric oxygen for combustion and travel at incredible speeds of over Mach 6 or 2 km per second. As a DRDO scientist put it, “The skill to ignite a rocket to attain such speeds is like lighting a matchstick in a hurricane.” The DRDO team had struggled for 15 years to master such hypersonic engine technology that only three countries—the US, Russia, and China—had so far achieved. Now, the team was ready to test the technology demonstrator it had developed.

On the launch pad the pencil-shaped, two-stage missile stood five metres tall. To punch the vehicle to a height of 30 km, the lower stage was fitted with an Agni booster rocket made of solid fuel. But it was the second stage that was a true marvel of technology. Barely six foot in height and wrapped in a heat shield, it looked like a miniature replica of a sleek aircraft with narrow wings and a tail. But there was nothing fragile about it. The missile was made of material that could withstand temperatures of over 2000 degrees centigrade or twice the melting point of steel. It could withstand the aerodynamic stress of air that is rammed into its combustion chambers at hypersonic speed without breaking up under the stress. Yet it could maintain its altitude and even conduct complex manoeuvres to acquire targets at a great distance that it was programmed to destroy. Nor was it short of power—it could maintain the hypersonic speeds (above Mach 5) at almost half the weight and size of conventional ballistic missile rocket motors.

So why is such a hypersonic cruise missile a significant step forward? When ballistic missiles were invented during World War 2, they were considered invincible as they flew at speeds faster than fighter jets and could hit targets at intercontinental distance if needed. But soon, anti-ballistic missiles (ABMs) were developed to act as a counter. To overcome ABMs, countries developed technology to unleash multiple warheads in a single launch to defeat anti-missile defence systems. Realising that this could lead to an endless arms race, the US and the erstwhile Soviet Union entered into a treaty to mutually limit the production of ABMs in 1972. (This treaty has since unravelled.)

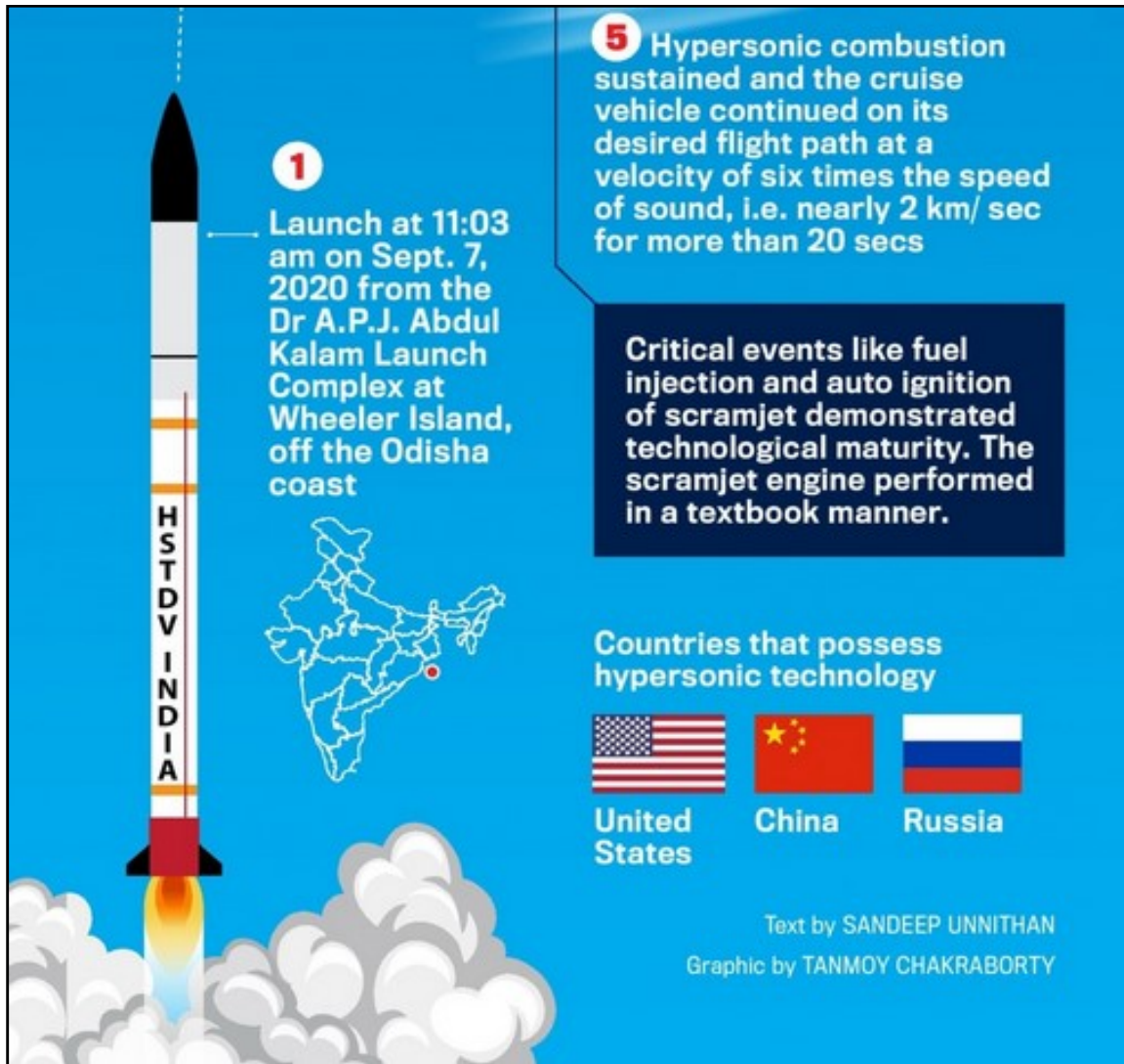
Meanwhile, missile technologists had been perfecting alternate rocket engines that did not need to carry both the fuel and oxidiser in tanks, like conventional ballistic rockets do. The engines were designed to employ atmospheric air just as a turbojet engine fitted to an aircraft does. But in this case, using the forward speed of the vehicle, air is ‘rammed’ through an inlet into the combustor at

high pressure to produce super high speeds. Called ramjets, these engines were initially sub-sonic. But as scientists mastered the technology, they were able to refine them to attain supersonic speeds. Hence the term scramjets or super combustion ramjets.



These engines, however, had a limitation—they could not travel at hypersonic speed or those that exceeded Mach 5, which was needed to go undetected by any country's defence system. Unlike ballistic missiles, whose trajectory can be accurately tracked and possibly neutralised, the hypersonic cruise vehicles can travel at hyper-fast speeds and undertake evasive manoeuvres that make them difficult to detect and destroy. Only in 2004 was the US able to develop and successfully test hypersonic speed scramjets that had the ability to cruise at a designated altitude and even make manoeuvres to acquire a target and destroy it. Russia and China followed. It became evident that hypersonic vehicles gave a decisive edge to the countries that possessed them.

Now, after working for 15 years on it, the DRDO was ready to test its first HSTDV, an acronym for Hypersonic Technology Demonstration Vehicle. In a heart-stopping 60 seconds, they would know whether their decade and a half's work would pay off or go up in flames. At precisely 11.03, the vehicle lifted off leaving a brilliant orange plume in its wake. In just 30 seconds it had attained a speed of Mach 6 or 2 km per second. The heat shield separated and the hypersonic cruise vehicle was injected at a height of 30 km.



Then came the critical moment. As scientists waited with bated breath, at the programmed time, the hypersonic engine ignited and flew for over 25 seconds—five seconds longer than it was scheduled to do—without losing momentum or the height it was injected at. It was guided into the Bay of Bengal where it splashed down as planned. Scientists glued to their monitors at the master control room were delighted to see that all the critical parameters of the engine and the vehicle had functioned according to expectations. DRDO chief G. Satheesh Reddy said, “By successfully demonstrating the complex air-breathing hypersonic technology, India has now entered the hypersonic regime.” Indeed, it has and much credit to DRDO for its hypersonic achievement.

<https://www.indiatoday.in/india-today-insight/story/drdo-joins-the-big-boys-with-a-hypersonic-achievement-1719610-2020-09-08>

India goes hypersonic: New missile technology may be answer to China's Navy

By H I Sutton

Cutting-edge hypersonic missiles could massively increase the potency of Indian Navy warships in a future conflict. India test fired its first hypersonic missile demonstrator on Monday. The test comes amid heightened tensions with China. There have been a series of clashes and shots fired on the border the same day. The rivalry between the two powers extends into the maritime domain where the rapid expansion of the Chinese Navy may soon reach into the Indian Ocean.

The indigenous Hypersonic Technology Demonstrator Vehicle (HSTDV) should prove technologies which can be incorporated into next generation weapons. This may be one way that the Indian Navy can counterbalance the Chinese Navy's move into anti-ship ballistic missiles.

The HSTDV test vehicle has been developed by DRDO (Defence Research and Development Organisation). It has a short range and does not carry a warhead. An anti-ship missile using the same technology could have a range of several hundred miles. But the increased speed, relative to current missiles, may come at the expense of range. Hypersonic missiles can still have a useful range however and their speed makes them extremely difficult to counter.



Artist's impression of a hypersonic missile launched from an Indian Navy destroyer. The missile would have a launch booster to get it up to the speed where the scramjet can take over.

The HSTDV launch appears to have been delayed since August. It was anticipated by open-source intelligence observers using the warning notices given to shipping in the area. Twitter account @detresfa_ reported a launch window of August 20-22, but this was subsequently postponed. The final notice closed airspace from 4:30 a.m. on September 7 to 8:30 a.m. on September 8. Whatever the cause of the delay, the test was reportedly a success.

DRDO is known to be working on a hypersonic anti-ship missile known as BrahMos-II. This will succeed the Indian Navy's BrahMos anti-ship missile, which is already supersonic. That flies at 3 times the speed of sound, known as Mach 3. Jointly developed with Russia, it is based on the P-800 Oniks missile and uses a ramjet to reach its high cruising speeds.

Ramjets are a type of jet engine that is mechanically simple but needs to be travelling at about the speed of sound to start producing thrust. For this reason they need a launch booster to get them up to speed.

Hypersonic missiles will be about twice as fast, flying at speeds in excess of Mach 6. They do this by using a scramjet, which stands for supersonic combustion ramjet. This is even simpler than a ramjet but needs to be going even faster to work.

The benchmark hypersonic anti-ship missile is the Russian 3M22 Zircon. This is only now entering service aboard warships and submarines. BrahMos-II, which is a joint Indian-Russia project appears to be very similar to Zircon and is possibly related. Exactly how the HSTDV relates to the Brahmos-II is unclear.

India's main rival, China, is rapidly expanding its naval capabilities. It will soon have at least three aircraft carriers and a host of large destroyers, frigates and submarines. While China is not reported to have a hypersonic anti-ship missile, it has a number of sophisticated weapons projects.

Many of its warships carry high performance anti-ship missiles. And they are complemented by anti-ship ballistic missiles which present their own challenges in defending against.

India's hypersonic anti-ship missiles will give Chinese Navy planners a headache however. In some respects they are the counter to China's increasingly potent naval fleet.

<https://www.forbes.com/sites/hisutton/2020/09/08/india-goes-hypersonic-new-missile-technology-may-be-answer-to-chinas-navy/#1c190da6d937>



Wed, 09 Sept 2020

Why DRDO's Successful test of hypersonic tech's a big leap forward

With the successful test, India enters an exclusive hypersonic club consisting of the US, Russia, and China

Defence Research Development Organisation (DRDO) on Monday, 7 September, successfully tested the indigenously-developed hypersonic technology demonstrator vehicle (HSTDV). This technology is crucial for India's several future defence projects. The HSTDV test was conducted from the Dr Abdul Kalam Island off the Odisha coast at 11:03 am to demonstrate the autonomous flight of a scramjet integrated vehicle.

Here is why this successful test has a big significance for the future of India's rocket technology.

What is HSTDV?

The HSTDV is an unmanned scramjet. It is a technology demonstrator of India's hypersonic speed flight capabilities. Hypersonic flight means it can cruise at a speed of six times the speed of sound ie Mach 6, and rise up to an altitude of 32.5 km in 20 seconds.



A model of the HSTDV (Photo Courtesy: DRDO)

How Does It Work?

The HSTDV cruise vehicle is mounted on a solid rocket motor, which takes it to a required altitude. Once it attains certain speed, the cruise vehicle will be ejected out of the launch vehicle. After that, the scramjet engine is ignited automatically and proceeds towards its target.

What is the Use of This Technology?

This technology demonstrator developed by the DRDO is used as a carrier vehicle for hypersonic and long-range cruise missiles. Apart from military use, it has civilian uses as well. According to DRDO, apart from long-range missiles, this technology can be used to launch small satellites at low cost. According to DRDO, with the successful testing of the technology demonstrator, India will be able to make its first hypersonic missile in the next five years.

What is a Hypersonic Missile?

Hypersonic missiles travel at speeds faster than ballistic and cruise missiles that are in service. They can carry conventional or nuclear payloads and can be used to intercept incoming missiles in the outer or the inner atmosphere. Hypersonic weapons are designed for increased survivability against modern ballistic missile defence systems and they are highly manoeuvrable as well.

How Many Countries Possess This Technology?

With the successful test on Monday, India enters an exclusive hypersonic club consisting of the United States, Russia and China. While India is in the initial stages of the testing, the other three countries have had these technologies for a while. They have already developed manoeuvrable hypersonic systems, with speeds of over Mach 5. This enables them to defeat the enemy's anti-air defence missiles.

<https://www.thequint.com/news/india/drdo-india-tests-hypersonic-technology-demonstrator-vehicle-hstdv>

THE ECONOMIC TIMES

Wed, 09 Sept 2020

DRDO successfully flight tests hypersonic vehicle at six times the speed of sound

New frontiers

In a historic mission today, India successfully flight tested Hypersonic Technology Demonstrator Vehicle (HSTDV), a giant leap in indigenous defence technologies. The DRDO, with this mission, demonstrated capabilities for highly complex technology that will serve as the building block for NextGen Hypersonic vehicles.

Six times the speed of sound

The hypersonic cruise vehicle was launched using an in-service strategic missile and taken to an altitude of 30 km. After separation from the missile, the cruise vehicle separated and attained a speed of Mach 6, or six times the speed of sound, for over 20 seconds.

The test proves that India now has the ability to achieve hyper speeds, validating critical technologies like performance of high temperature materials, aerodynamic design for sustained flight and the maturity of the scramjet engine.

Next step

With the technology proven, DRDO would move to the next stage of designing and testing weapons in the hypersonic category. The applications include extended air defence, surveillance (UAVs) and developing missiles with virtually global targeting range.

Future applications

The vehicle may need more validation tests but the technology demonstrated will pave the way for a future series of missiles that can be made by India. The hypersonic missiles project – cruise missiles flying at several times the speed of sound – will be a critical weapon for the future. Cheaper and more manoeuvrable than ballistic missiles, these future weapons will be significantly more lethal than the current range of cruise missiles like the Brahmos.

The technology also has applications for space launch programmes and can be used to launch small satellites in a more cost-effective manner. In the US, a similar programme is underway to develop a common hypersonic vehicle that could launch space missions as well as strategic missiles.

What it means

India has now joined a select group of nations that have demonstrated hypersonic technology. This small club includes the US, Russia and China. After the Anti-Satellite Test conducted last year, this is the biggest achievement by DRDO in terms of proving new technology.

<https://economictimes.indiatimes.com/news/defence/drdo-successfully-flight-tests-hypersonic-vehicle-at-six-times-the-speed-of-sound/elite-tech-club/slideshow/77978591.cms>

डीआरडीओ ने स्क्रेमजेट इंजन की तकनीक तो बना ली, लेकिन ब्रह्मास्त्र या पुष्पक विमान बनने में लगेंगे कई साल!

शशिधर पाठक

सार

- अमेरिका, रूस, चीन के पास पहले से हैं तकनीक
- इंजन बनाने में सफलता बड़ी कामयाबी
- अब उपग्रह छोड़ना होगा आसान, पिछले साल अगस्त में इसरो ने किया था परीक्षण

विस्तार

पूर्व राष्ट्रपति एपीजे अब्दुल कलाम के सपने को सपने को पिछले साल इसरो ने एक उम्मीद की किरण दिखाई थी, अब डीआरडीओ ने स्क्रेमजेट इंजन (हाइपरसोनिक टेक्नोलॉजी डेमोंस्ट्रेशन व्हीकल-एचएसटीडीवी) तकनीक का प्रदर्शन करके हकीकत में बदलने का भरोसा दे दिया है। हाइपरसोनिक स्क्रेमजेट इंजन की तकनीक आने के बाद भविष्य में भारत के अर्जुन द्वारा छोड़े गए ब्रह्मास्त्र और रावण द्वारा इस्तेमाल किए गए पुष्पक विमान को विकसित करने का रास्ता साफ हो गया है। डीआरडीओ के एक पूर्व प्रमुख का कहना है कि हमें यह सपना पूर्व राष्ट्रपति एपीजे अब्दुल कलाम दिखाया करते थे।

क्या था कलाम का सपना ?

पूर्व राष्ट्रपति कलाम रक्षा विज्ञान के उम्दा वैज्ञानिक थे। पृथ्वी, अग्नि, आकाश जैसी मिसाइलों को विकसित करने का दौर उनके समय में आरंभ हुआ था। जब वह डीआरडीओ प्रमुख थे। कलाम ने नौसेना के एक सार्वजनिक कार्यक्रम में भी कहा था कि आने वाले समय में ऐसी मिसाइल तकनीक विकसित करने की आवश्यकता है, जो दुश्मन के लक्ष्य को भेदकर वापस आ जाए। कलाम की इस परिकल्पना के बारे में

डीआरडीओ के पूर्व वैज्ञानिक एम नटराजन ने 2009 में अमर उजाला को बताया था। नटराजन के अनुसार भारत स्क्रेमजेट इंजन की परियोजना पर काम कर रहा है। यह महत्वाकांक्षी परियोजना है और इसके विकसित होने के अंतरिक्ष में उपग्रह भेजना, दूर देशों की हवाई यात्रा करना तथा दुश्मन के ठिकाने को पलक झपकते ही ध्वस्त कर देना बहुत आसान हो जाएगा। यानी भारत ब्रह्मास्त्र और पुष्पक विमान की तकनीक हासिल कर लेगा।

क्या है स्क्रेमजेट इंजन प्रणाली ?

यह एक ऐसा इंजन है, जिसके माध्यम से भविष्य में कोई ध्वनि से भी 6-9 गुना तेज गति वाला नागरिक उड़्डयन विमान, फाइटरजेट, उपग्रह ले जाने वाला रॉकेट विकसित किया जा सकता है। रक्षा वैज्ञानिकों के मुताबिक यह इंजन वायुमंडल से ऑक्सीजन लेकर अपना ईंधन खुद वायुमंडल में ही बनाएगा, इस्तेमाल करेगा और लक्ष्य पूरा करके वापस भी आ सकेगा। इसके लिए स्क्रेमजेट इंजन में पहले से हाइड्रोजन होगी। इस तरह से किसी भी उपग्रह को छोड़ने में न केवल बड़ी सहायता मिलेगी, बल्कि खर्च भी बहुत कम हो जाएगा।

इंजन तो आ गया, ब्रह्मास्त्र और पुष्पक विमान बनने में लगेगा समय

डीआरडीओ ने स्क्रेमजेट इंजन तकनीक का प्रदर्शन किया है। यह एक बहुत बड़ी कामयाबी है। यह तकनीक अमेरिका और रूस के पास काफी पहले से है। वह इसके अगले चरण का अनुसंधान कर रहे हैं। चीन ने भी इसे विकसित



DRDO-HSTDV - फोटो : DRDO

कर लिया है। जबकि जापान और जर्मनी जैसे देश भी विकसित करने की कतार में हैं। पिछले साल डीआरडीओ ने 19 अगस्त को स्कैमजेट तकनीक को लेकर परीक्षण किया था। एक साल बाद डीआरडीओ ने इस तकनीक का सफलतापूर्वक परीक्षण किया है। लेकिन अब इंजन तकनीक के विकास के बाद आगे की परियोजनाओं का नतीजा आने में समय लग सकता है। भविष्य में इस तकनीक से ब्रह्मास्त्र जैसा अचूक और लक्ष्य भेदने के बाद योद्धा के तरकश में लौट आने वाला अस्त्र या रावण के पुष्पक विमान की तरह बिना ईंधन के हवा में उड़ने वाला पुष्पक विमान विकसित किया जा सकता है।

साढ़े तीन घंटे में पहुंच सकते हैं लंदन, साढ़े चार घंटे में अमेरिका

अभी नई दिल्ली के इंदिरा गांधी अंतरराष्ट्रीय हवाई अड्डे से अमेरिका के शिकागो अंतरराष्ट्रीय हवाई अड्डे पर पहुंचने में हवाई जहाज से करीब 15-16 घंटे लगते हैं। लंदन जाने में 10 घंटे से अधिक लगते हैं। रक्षा वैज्ञानिकों का कहना है कि भविष्य में स्कैमजेट इंजन प्रोपल्शन प्रणाली आधारित नागरिक उड़य विमान को विकसित किए जाने के बाद यह दूरी महज साढ़े तीन घंटे (लंदन) और साढ़े चार घंटे में (वाशिंगटन) पूरी की जा सकती है। एक ही स्कैमजेट इंजन प्रोपल्शन प्रणाली पर कई उपग्रहों को अंतरिक्ष में भेजा जा सकता है। इतना ही नहीं मिसाइल को दुश्मन के ठिकाने तक ले जाने प्रणाली के रूप में इस्तेमाल किया जा सकता है।

<https://www.amarujala.com/india-news/drdo-developed-the-technology-of-hstdv-scamjet-propulsion-engine-but-it-will-take-many-years-to-become-a-brahmastra-or-pushpak-aircraft?pageId=4>



Tue, 08 Sept 2020

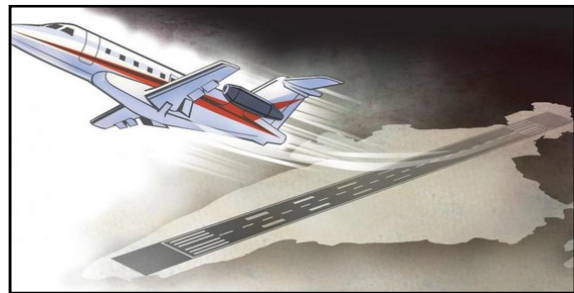
Quest for national civil aircraft and the way forward

Lack of focus and complex process of decision-making are some ills that have haunted civilian aircraft development in India. A recent announcement by the PM gives hope

By G Madhavan Nair

I was listening to the address of the prime minister to the Indo-US business conclave during the first week of July. His announcement that India needs nearly 1,000 medium-capacity aircraft for connecting small towns to metros and inviting investors to come forward was an exciting one for the aeronautics community in India. This has been a dream for many of us for a quarter of a century.

Though we have made remarkable progress in the field of rocket and missile technology, we were hesitant to take up the development of an indigenous passenger aircraft for civilian use. It was the late Dr Abdul Kalam who mooted the idea of giving a thrust for aircraft development when he was president of the Aeronautical Society of India in the early 90s. It only partially succeeded. While Kalam was the DRDO chief, he launched the indigenous development of a light combat aircraft (LCA).



A separate entity, Aeronautical Development Agency (ADA), was created for this purpose. It was an autonomous society under DRDO, knowing well that such sophisticated activities cannot be run under strict government controls. Today, we have a light combat aircraft of our own developed by ADA, produced by HAL and inducted into all defence services. An advanced version of this will make India self-reliant in this field.

The National Aerospace Laboratories (NAL) was established way back in 1959 under CSIR in 1959, before ISRO took birth. Its mandate was to carry out research, establish test facilities and undertake development of small and medium class aircraft for civilian use. It was headed by great scientists like Dr Velluri, Prof. Dhawan and Prof. Narasimha. They established wind tunnels for aerodynamic characterisation and new technologies in composite material back in the 70s. India's first satellite launch vehicle SLV3 was benefitted by the technical expertise at NAL and the facilities there. The NAL also developed two-seater trainer aircraft like Hansa.

The need for creating indigenous capability for aircraft was felt and a programme was initiated in 1980. The feasibility study itself took almost a decade and in 1991, a project for the development of a 12-seater aircraft development was started. The initial plan was to implement it with support from the then USSR. On its breakup, this fell through as did the cryogenic rocket for ISRO. Finally we decided to go ahead in 1999 on our own and the first flight of Saras, a 12-seater aircraft, took place in 2004. Two prototypes were realised as part of this programme.

Several hours of flight trials successfully demonstrated its capability to take off from a short runway; it had most modern flight control systems, a novel concept of pusher engines mounted at rear, etc. The initial model had a mass overrun of nearly 900 kg and the NAL had plans to optimise the same through extensive use of composite material. But during the flight proving of the second prototype in March 2009, an unfortunate crash took place in which the precious lives of two experienced pilots and one flight engineer were lost. A detailed probe concluded that the failure was caused by a wrong procedure adopted for switching off the engine and restarting it in flight. The sequence was tried for the first time and there was apparently a communication gap between the engine designer and the team that evolved the flight test programme. There was nothing wrong with the aircraft design or realisation. Since then, several attempts were made to put back the programme on track but it has not succeeded. Had it been pursued vigorously, we would have had a small 12-seater aircraft doing air taxi air ambulance and military surveillance. I understand a modified version with 18-seat capacity to primarily meet the requirements of defence has been started by NAL recently.

While all these were happening, a proposal to set up a high powered committee (HPC NCAD) was approved by the government in 2010 to assess the feasibility of realising indigenously a 90-seater passenger aircraft. It had eminent scientists like Prof. Narasimha, Dr Kota Harinarayana, administrators like Chandrasekhar, etc. Dr Upadhaya, Director of NAL, was convenor and I had the opportunity to chair the National Civil Aircraft Design (NCAD). We assembled a team of 100 experts: some seniors who had retired from service and 50% young engineers. Within a short time, the market survey was conducted based on which detailed specifications and a preliminary design report were prepared. Using this, a detailed project report for implementation was drawn up. It was submitted within a record time of one year in 2011 to the government.

The major recommendations were: the country needs nearly 300 90-seater aircraft to provide regional connectivity; based on market survey and technology assessment, a configuration using proven turbo fan engine similar to the Embraer aircraft was finalised; indigenous development and production is feasible using the knowledge and experience of NAL, HAL and ADA; infrastructure available with government institutions for technology and design development is to be maximally used; the development phase was to be fully funded by the government.

The report presented business models, management structures and proposals for a joint venture. The Planning Commission reviewed the HPC report and recommended that such a programme is required with government funding for development phase and JV mode for series production. The general consensus was such efforts would enable further development of high technology industry in India and integration into the global aviation industry. In-principle approval was given by the then PM in 2012. In 2013, the Centre decided that the NCAD may be implemented jointly by NAL and HAL through a special purpose instrument and a seed money of `10 crore was sanctioned.

Still the project got into turbulence with basic questions on use of old propeller engines or configuration using turbo fan engines as in all modern passenger aircraft. This was debated at HPC meetings and it was recommended that we go for a turbo fan engine for passenger convenience,

speed and availability of engine, as propeller configuration similar to the ATR, which was tried by several operators for short haul was a failure. Non-availability of a modern engine and overall discomfort of low speed, added noise and lack of adequate AC were other disadvantages. Still NAL was confused and generated a new proposal for a propeller version virtually derailing the NCAD proposal. The only advantage being projected was it was suited for military transport needing operation from extremely small airstrips. But the passenger aircraft configuration may not suit military transportation, which would need a wide body configuration. The development of an aircraft for military use has to be delinked.

As there was no progress since 2013, the matter was later brought to attention of Dr Harsh Vardhan, the then minister of S&T under which NAL and CSIR come. He took immediate action as confirmed during his foundation day speech in 2016 in which he said that the matter was being taken up with the civil aviation ministry. But by that time, the configuration issue was opened up.

In a statement placed before Parliament, it was stated that the government is considering developing regional transport aircraft as well as other types of planes and helicopters. In a written reply to the House, Union minister Jayant Sinha said the issue of development of a Regional Transport Aircraft (RTA) under the NCAD programme in India was considered during a meeting on 18 May 2018. Further actions have been taken up as per the decisions at the meeting.

Now, since the civil aviation ministry is responsible for realisation of civilian aircraft and associated ecosystems, I am sure much more focus will be there for NCAD. As seen in the past, the wandering nature of R&D, lack of focus and complex process of decision-making are some of the ills haunting civilian aircraft development in the country. Successful management models as demonstrated by atomic energy and space programmes have to be adopted for the NCAD programme of nearly `20,000 crore (much of which will be recovered during the production phase), which needs to synthesise the efforts of multiple agencies, education institutions and industry.

(G Madhavan Nair, Former ISRO Chairman)

<https://www.newindianexpress.com/opinions/2020/sep/08/quest-for-national-civil-aircraft-and-the-way-forward-2193926.html>



Wed, 09 Sept 2020

India-China border clashes: How the post of CDS has impacted the chain of command in Indian military

A look at how the creation of the post of Chief of Defence Staff — a long-pending reform — has come to bear on decision-making and strategy in the armed forces

By Ranjit Bhushan

The appointment of General Bipin Rawat as Chief of Defence Staff (CDS) on December 30, 2019, was justifiably hailed as one of the major initiatives of the Modi government. For many, it was a step long overdue. Most professional militaries, with CDS or equivalents, have added muscle to their war-fighting capabilities.

The announcement of putting in place a CDS, which came from Prime Minister Narendra Modi during his 2019 Independence Day speech, stressed upon the urgent need for a joint culture for the three services. Given India's recent military history, in the decades preceding the Kargil conflict, joint service endeavours were largely a cosmetic exercise.

The Kargil war heightened the appreciation that modern wars cannot be fought with outdated structures, where the army, navy and the air force conducted operations independently. It was no longer a state secret that military operations required a great deal of synergy — vast technological changes, an altering battlefield milieu, appearance of new threats and challenges, cyber and hybrid wars and, last but not the least, nuclear warfare. All these made an integrated approach not just desirable, but an imperative.

A longstanding demand

To be sure, the idea was not new. Post-1947, Indian military had realised the importance of joint endeavours. This vision was translated into reality by the setting up of joint institutions like the National Defence Academy (NDA), the Defence Services Staff College (DSSC) and the National Defence College (NDC). These institutions covered a wide canvas, from pre-commissioning training to mid-career training, culminating in the highest level of formal training an officer undergoes.

But somewhere along the way, the focus was diffused enough for the services to slip into separate compartments. Over a period, this compartmentalisation has become institutionalised. The demand for joint approaches came up, mostly at the conclusion of each war that India fought. The CDS has been in the recommendation stage of several committees since as early as the 1965 Indo-Pakistan war. The most notable among them were the LK Advani-led Group of Ministers (GoM) after the Kargil war and the Naresh Chandra Task Force (NCTF) of 2012.



To that extent, CDS General Rawat has been going about his work in right earnest. He is working on redesigning existing military commands into theatre commands and establishing new joint commands that will combine the resources and assets of the three defence forces, based on threats at India's borders with its neighbours. "The work on establishing theatre commands will begin next year and will be completed within three years," the CDS told reporters earlier this year. In place of the 17 commands that India has now, there could be five to six integrated commands.

There are several new theatre commands on the anvil. The work will start first with establishing an Air Defence Command that will combine the air assets of the three services, the CDS said. There will also be a Peninsula Command, which will be responsible for India's Exclusive Economic Zone.

This will lead to 'seamless integration' between the navy's eastern and western commands with coordination being done by the naval headquarters in Delhi. There is also a proposed joint training and logistics command, in addition to a space command.

Add to this, theatre commands created out of the existing northern, western and eastern commands. Some of these like Air Defence will come under the Indian Air Force while the Peninsula Command would be under the Indian Navy.

Let's hear the other side

There are sceptics, however, who are not too impressed with this proposed restructuring of the Indian military forces. Analyst Pravin Sawhney, who retired after 14 years as an officer in the Indian Army and now edits *Force*, a news magazine on Indian defence, believes that the CDS is determined to implement massive military reforms involving structural, operational, and operational support and logistics amounting to hundreds of crores of rupees spread over a decade, which he had himself initiated as army chief.

"These reforms are predicated on the two-front war fighting fantasy. This scheme of things has two fundamental flaws. One, as CDS, he should now consult other services chiefs to incorporate their professional opinion. And two, Ladakh, which has been a gamechanger for Indian military, should be studied carefully for lessons learnt. So, the reforms need to be reviewed before implementation. The two-front war thinking will be found to be not valid in a changed situation where both LoC and LAC have become active," he told this writer.

In addition, what was never said, but mostly understood and implied, was that the appointment of a CDS would also tinker with the delicate chain of command in the higher military, considered a *sin qua non* in all affairs concerning the defence services. The question to ask is this: has the appointment of a CDS whittled down the role of the Indian Army chief in particular and the two other service chiefs in general? Given the current standoff with China, who would be operationally in command, should things get sticky along the LAC?

As per a 2001 Group of Ministers' (GoM) observation, the CDS would be a four-star flag officer from either of the three services, who will be '*primus inter pares*' (first among equals) with the other three chiefs and function as the 'Principal Military Adviser' to the Defence Minister and the Cabinet Committee on Security (CCS).

Pravin Sawhney believes the situation is tenuous with the "CDS as the new tri-service boss, and the three service chiefs like his staff officers". He is convinced that the chain of command, considered sacrosanct in the military, is being broken. "Why should the CDS be briefed by officers when he goes to Ladakh? It is the job of the service chiefs to brief him," he asserts.

Somehow, the CDS has assumed the role of the *de facto* army chief. During the ongoing Sino-India standoff, the Indian Army chief has issued no statement on the tense border situation, a role that traditionally 26 of his predecessors have enjoyed. While experts believe that the appointment of a CDS was bound to whittle down the position of the three service chiefs, General Mukund Naravane has assumed the lowest-ever profile of a serving Indian army chief, even though all the three service chiefs remain head of operations in their domain.

One official who has worked with successive army chiefs, however, believes that the current positioning and issuing statements on China are tactical. "The army chief is deliberately

maintaining a low profile, while the CDS does the talking. It is the way things should ideally work,” he points out.

Army planners certainly had a vision about the role of the CDS. Wrote a former vice-chief of army staff, Lt Gen Vijay Oberoi, in a column last year: “We must visualize the CDS, not as just another appointment in the higher defence structure, but as the head of an entire eco-system, which should be set up simultaneously or soon after appointing a CDS, so that the PM’s directions for joint systems, as a precursor of change are fully met.”

Some others like Lt Gen Satish Dua (retd), former Corps Commander in Srinagar, who has also served as Chief of Integrated Defence Staff to the Chairman of the Chiefs of Staff Committee, believes that the Department of Military Affairs (DMA) is the biggest game changer.

In a crucial order issued on January 9, 2020, titled ‘*Allocation of Work and Staff between Department of Defence and newly created Department of Military Affairs*’, the new rules of business were clearly laid down. With the decision to amend the Government of India (Allocation of Business) Rules, 1961, to create a new Department of Military Affairs, the allocation of subjects between the Department of Defence (DoD) and DMA has been demarcated. The DMA, currently headed by Gen. Rawat, is going to play a crucial role in the Ministry of Defence.

Gen. Dua believes that the transition to CDS may take a few years, as it takes time for people to adjust to change. “The CDS is the professional head of the armed forces and, as a strategic military commander, he will translate national objectives into military objectives and create military capabilities accordingly,” he told this writer.

As for the claim made by some that the CDS is a political appointee, Gen. Dua queries: “How is it a political appointment? Just because he has by necessity, been appointed by the leadership, who are also politicians, that does not make him a political appointee.”

Lt Gen AK Singh (retd), Distinguished Fellow with Centre of Land Warfare Studies (CLAWS) and R Chandrashekhar, erstwhile member of the Armed Forces Headquarters Civil Service in their well-presented joint article, have put forth the view that “The simultaneous creation of a Department of Military Affairs as a separate vertical within the Ministry of Defence with the CDS as its ex-officio Secretary are each and together tectonic shifts that have moved the balance in civil-military relations to a new normal. It has also disruptively altered the entire edifice of the structure of decision making relating to matters of military.” Clearly, the test of such thrust and parry may come sooner than expected.

(Ranjit Bhushan is a senior journalist based in Delhi.)

<https://www.moneycontrol.com/news/trends/expert-columns-2/india-china-border-clashes-how-the-post-of-cds-has-impacted-the-chain-of-command-in-indian-military-5812951.html>

कल भारतीय वायुसेना में शामिल होगा राफेल, फ्रांस के रक्षा मंत्री भी कार्यक्रम में शामिल होंगे

नई दिल्ली: फ्रांस में निर्मित पांच राफेल लड़ाकू जेट विमानों को भारतीय वायुसेना में शामिल करने की औपचारिकताएं गुरुवार को पूरी की जाएंगी। इसके लिए अंबाला एयरबेस पर आयोजित औपचारिक समारोह में रक्षा मंत्री राजनाथ सिंह के साथ फ्रांसीसी रक्षा मंत्री फ्लोरेंस पार्ले और भारत के शीर्ष सैन्य अधिकारी भी शामिल होंगे।

सैन्य अधिकारियों ने बताया कि समारोह में भाग लेने के लिए फ्रांस की महिला रक्षा मंत्री बृहस्पतिवार सुबह ही भारत पहुंचेंगी और दोपहर बाद वापस अपने देश लौट जाएंगी। अधिकारियों ने बताया कि इस समारोह के बाद सिंह और पार्ले अंबाला में ही द्विपक्षीय वार्ता में हिस्सेदारी करेंगे, जिसका मकसद दोनों देशों के बीच रक्षा व सुरक्षा सहयोग को और ज्यादा मजबूत करना है। इस समारोह के साथ ही वायुसेना में पिछले 23 साल के दौरान पहली बार नए विमान शामिल होंगे। आखिरी बार 1997 में रूस से सुखोई जेट विमानों की खरीद की गई थी।



राफेल विमान - फोटो : twitter.com/IAF_MCC

पांच राफेल जेट विमानों का पहला बैच इसी साल 29 जुलाई को भारत पहुंच गया था। पहले बैच का आगमन 2016 में भारत की तरफ से 59 हजार करोड़ रुपये में 36 विमानों की खरीद का अंतर सरकारी समझौता फ्रांस की सरकार के साथ करने के करीबी चार साल बाद हुआ है। इन 36 विमानों में से 30 लड़ाकू क्षमता वाले हैं, जबकि 6 दोहरी सीट वाले ट्रेनिंग विमान हैं। हालांकि आवश्यकता पड़ने पर इन ट्रेनिंग विमानों को भी युद्ध के मैदान में उतारने के लिए हर क्षमता से लैस किया गया है।

फ्रांस की एयरोस्पेस कंपनी दसॉल्ट एविएशन द्वारा निर्मित राफेल विमान को भारतीय वायुसेना के बेड़े में शामिल करने की औपचारिकताएं अभी तक पूरी नहीं की गई थीं। कंपनी ने भारतीय वायुसेना को पहले बैच में 10 राफेल विमानों की डिलीवरी दी थी, जिनमें से 5 को भारतीय पायलटों की ट्रेनिंग के लिए फिलहाल फ्रांस में ही रखा गया है। राफेल विमानों के पहले स्क्वाड्रन को अंबाला एयरबेस पर, जबकि दूसरे स्क्वाड्रन को पश्चिमी बंगाल के हासिमारा एयरबेस पर तैनात किया जाएगा।

पांच विमान नवंबर में मिलेंगे, 36 विमानों की और खरीद पर बात

सूत्रों का कहना है कि पांच राफेल विमानों का दूसरा बैच इसी साल नवंबर में भारत पहुंचने की संभावना है। सभी 36 विमानों की डिलीवरी 2021 के अंत तक हो जानी है। सूत्रों ने यह भी बताया कि चीन और पाकिस्तान के साथ लगातार बढ़ते तनाव को देखते हुए सरकार ने 36 राफेल विमानों के एक और बैच की खरीद की तैयारी चालू कर दी है। अंबाला में पार्ले और राजनाथ के बीच वार्ता में सबसे अहम मुद्दा इन विमानों की खरीद का ही है।

भावनात्मक होगा वायुसेना के लिए पल

राफेल विमानों की नई फ्लीट उस 17 स्क्वाड्रन का हिस्सा होगी, जिसे पिछले साल 10 सितंबर को दोबारा सक्रिय किया गया था। यह स्क्वाड्रन वास्तव में एक अक्टूबर, 1951 को पहली बार अंबाला एयरबेस पर ही गठित की गई थी। गठन के बाद 1955 में अपने पहले जेट फाइटर विमान द लीजेंडरी डि हाविलैंड वैंपायर को हासिल करने वाली 17

स्क्वाड्रन ने पिछले कई दशक के दौरान बहुत सारे तमगे देश की सुरक्षा में काम करते हुए हासिल किए हैं। इसके चलते भारतीय वायुसेना के लिए इस स्क्वाड्रन में राफेल विमान का शामिल होना एक भावनात्मक पल जैसा अहसास होगा।
<https://www.amarujala.com/india-news/rafale-fighter-planes-will-be-inducted-in-indian-air-force-today>

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Read to Lead

Wed, 09 Sept 2020

China continues aggression from IOR to Pacific Ocean; Quad to meet, discuss strategy to control rogue Chinese Navy

Closer home, the foreign ministers of India, US, Australia and Japan, the members of the Quad is expected to meet soon to chalk out plans to deal with the growing Chinese presence in the Indo-Pacific region

By Huma Siddiqui

Even as US-led alliance and India are looking for ways to counter China's growing assertiveness in the Indo-Pacific Region, Beijing is flexing its muscles all the way to South America.

Closer home, the foreign ministers of India, US, Australia and Japan, the members of the Quad is expected to meet soon to chalk out plans to deal with the growing Chinese presence in the Indo-Pacific region.

According to the experts, "The formation of Quad is a very significant step. It would arrest the unchallenged behaviour of the rogue Chinese Navy in South China Sea (SCS) and also bring in checks and balances for their Naval operations in IOR (Indo Pacific Region)."

Though the dates have yet to be formalised for the meeting to be held in New Delhi, the External Affairs Minister Dr S Jaishankar at a recent interaction with a think tank suggested as much. "The fact that this meeting will be held in person despite the restrictions and precautions necessitated by the pandemic is indeed significant," opines Commodore Anil Jai Singh, Indian Navy Veteran & Vice President Indian Maritime Foundation.

"The effectiveness of the Quad as a security framework committed to ensuring the security of the region will depend on its ability to acknowledge ASEAN centrality and include other nations in the region including both ASEAN and non-ASEAN members," he says.

Will the Quad be able to control the growing Chinese presence in Indo-Pacific? What do experts say?

Commodore Anil Jai Singh, Indian Navy Veteran & Vice President Indian Maritime Foundation tells Financial Express Online, "The four Quad members have clearly articulated their objective of adherence to a rules-based international order and a 'Free and Open Indo-Pacific'. In the absence of an institutionalised framework or charter, the Quad has remained just that – a dialogue. It has identified many areas of convergence but on the more significant regional security issues there have been divergences which have been driven by national interest and regional perceptions leading many to question the very relevance of the Quad."

Within the Indo-Pacific region too, the perceptions of the Quad have varied. ASEAN perceived it as an extra-regional grouping since the Quad failed to appreciate ASEAN's centrality to the region leading to one Foreign Minister describing it as a solution in search of a problem.



“The ‘problem’ which was spoken about in hushed tones so far has now been acknowledged. China’s recent (mis)conduct in the region commencing with its concealment of the coronavirus leading to its spread across the globe and becoming a pandemic which has ravaged populations and economies and shows no sign of abating followed by its extremely aggressive conduct in the last few months – be it the transgression across the Line of Actual Control with India in the high Himalayas or its belligerence in the South China Sea has led to a considerable pushback which has perhaps even taken China by surprise. It is on a collision course with the USA, has provoked India on the sensitive border issue, continues bullying Japan in the East China Sea and has launched an economic broadside against Australia warning it of dire consequences. Its debt trap diplomacy stands cruelly exposed and its behaviour with its Uighur population and planned re-education of Tibet is nothing short of genocide. Its draconian suppression of Hong Kong and its provocative conduct with Taiwan is having exactly the opposite effect than what China meant it to be,” the former submariner says.

What of the Quad?

According to Commodore Anil Jai Singh, “It is unlikely that the Quad will become a security alliance of like-minded partners anytime soon, if at all. India remains committed to ‘strategic autonomy’ as the cornerstone of its foreign policy while both Japan and Australia are already allied with the US. India is also the only Indian Ocean power in the Quad and would require a greater commitment from the other three on the region west of the Malacca Straits. Japan perhaps understood this well but with Prime Minister Shinzo Abe’s departure; a formal acknowledgement from his successor will be awaited.”

The forthcoming meeting will therefore be significant in realigning the roadmap taking into cognisance China’s aggressive behaviour now and in the future, reiterate its commitment to a free and open Indo-Pacific and develop a coordinated approach towards addressing the fallout of the pandemic in human and economic terms.

Sharing his views, former spokesperson of Indian Navy, Capt DK Sharma says, “Importance of QUAD is gaining significance in the backdrop of the assertive behaviour of PLA Navy in the South China Sea (SCS) and also in the Indo Pacific region for the last few years. The Chinese Navy is denying the legitimate rights of use of Global commons to its neighbours and have staked claim to the entire South China Sea by promulgating an ever-shifting Nine-Dash line.”

“The littorals of the resource-rich SCS are not being allowed to do an exploration of natural resources including oil and gas extraction, minerals extraction and fishing etc. As per the UNCLOS, seafarers have a right to freedom of navigation in global commons as also of overflight, to which the Chinese have an objection. The forming of QUAD is a step to ensure that coercive tactics of PLA Navy is nipped in the bud and is not allowed to propagate as the Chinese Navy is spreading its area of influence by making bases all across the IOR,” observes the former spokesperson of the Indian Navy,” Capt Sharma concludes.

Meanwhile — China goes belligerent in the Pacific Ocean

Media reports indicate that China has been increasing its presence in the US’ backyard. Earlier this month China has gone fishing in the Pacific Ocean. While the world was fighting the COVID-19 pandemic, Ecuadorian officials have claimed that around 325 vessels have sailed close to its exclusive economic zone on the Galapagos Islands. Made up of 127 different islands, the Galapagos has been declared a Unesco World Heritage site.

Some of the boats had turned off their satellite tracking system and were almost nine nautical miles in the waters which are controlled by the Ecuadorian government.

The US Secretary of State, Mike Pompeo has described Chinese activity in the area as “deeply disturbing”, according to the media reports.

Sharing his view with Financial Express Online, Ravi Bangar, former Ambassador of India to Colombia & Ecuador says, “This is not the first time. China’s activities there were reported in 2017. This is China’s way of sending a message to the US as compared to US activities in SCS. This demonstrates that China has the capability to extend its reach in the US’ backyard. The flotilla

of over 300 fishing boats has been just 233 miles off the EEZ of Galapagos, so China can claim that it is in the international waters and respecting Ecuador's sovereignty."

"As for Ecuadorian request to embark these vessels, China has offered consultations. In my view, Ecuador's may make noise in the public domain but with the economic conditions and impending elections there early next year, they are unlikely to put much pressure on China. Not to forget China's economic assistance to and trade with Ecuador since the days of President Correa," adds Ravi Bangar, former High Commissioner to Cyprus.

<https://www.financialexpress.com/defence/china-continues-aggression-from-india-to-pacific-ocean-quad-to-meet-discuss-strategy-to-control-rookie-chinese-navy/2077925/>

Science & Technology News

THE TIMES OF INDIA

Wed, 09 Sept 2020

Hyderabad: Gaganyaan cosmonauts' trip to moon forged by Midhani

By Ch Sushil Rao

Hyderabad: India's first human spaceflight to the moon planned for next year by the Indian Space Research Organisation (Isro) will have three cosmonauts sitting in a titanium chamber, the specialised material for which has been provided by Hyderabad-based Mishra Dhatu Nigam Limited (Midhani). The defence public sector enterprise has already supplied the first consignment of the material needed in the fabrication of the chamber.

"In one stroke, we have met the requirement for Gaganyaan," Midhani chairman and managing director Sanjay Kumar Jha told TOI. He said titanium alloy, light in weight and suitable for the manned moon mission, was supplied after passing stringent tests. "It was challenging and with the technology we have what was needed was provided," Jha said.

Four IAF personnel have been selected for training in Russia for the journey to the moon.

Midhani associated with Isro in all projects so far

Three of them will be on board when Isro launches Gaganyaan, scheduled for December 2021. Their training began on February 10, just a month before the Covid-19 lockdown.

Midhani has been associated with Isro in all its projects so far. The material for the rocket motor casing for PSLV and GSLV vehicles have also supplied by the PSE, apart from the material for the fuel tank and the engine from which they are fired.

"One engine has 15-20 grades of steel, titanium, super alloys, and nickel-based alloys. All these material technologies are used for space applications," Jha said about the specialised materials that are supplied for space programmes of Isro. Titanium is already in the product list of Midhani but what is being provided to Isro for fabrication of the chamber in which the astronauts will sit is of a grade that meets higher specifications. "The Gaganyaan mission will be a huge achievement for India, Isro and for us at Midhani," Jha said. A spokesperson of Isro told TOI from Bengaluru that Gaganyaan was on schedule. "We have not revealed names of the astronauts-elect yet," he said.



SPACE STAR

- ▶ 3 Indian cosmonauts will make the moon trip sometime next year
- ▶ They will be in a titanium chamber which city-based Midhani help built
- ▶ All material for Isro programmes, including PSLV and GSLV, provided by Midhani

Meanwhile, the Research, Development & Production Enterprise Zvezda under the contract of Glavkosmos with the Human Spaceflight Centre of Isro has started manufacturing personal flight equipment for the Indian cosmonauts. This was announced on September 7.

Glavkosmos JSC is a subsidiary of the Russian space corporation Roscosmos. This is where the cosmonauts are trained. Zvezda produces spacesuits. "On September 3, Indian cosmonauts who have been training for a spaceflight in Russia under the contract of Glavkosmos visited Zvezda where anthropometric parameters were measured for subsequent production of spacesuits. Contract also provides for production of individual seats and custom-made couch liners," CEO of Glavkosmos Dmitry Loskutov said on the company's website.

<https://timesofindia.indiatimes.com/city/hyderabad/hyderabad-gaganyaan-cosmonauts-trip-to-moon-forged-by-midhani/articleshow/78007545.cms>



Wed, 09 Sept 2020

Researchers use waveguides for sensitive protease monitoring

For the first time, researchers have detected protease activity with surface-enhanced Raman spectroscopy (SERS) performed using a tiny waveguide. The work paves the way to real-time, label-free lab-on-a-chip protease monitoring, which could offer a high-throughput approach to screen for new drugs that inhibit proteases involved in disease.

Proteases break down the peptide bonds that hold proteins together. They are important drug targets because of their involvement in many diseases, including cancer, Alzheimer's disease, and arthritis.

Nina Turk from the IMEC research center at Ghent University in Belgium will present the new research at the all-virtual OSA Frontiers in Optics and Laser Science APS/DLS (FiO + LS) conference to be held 14-17 September.

"We hope that our interdisciplinary approach can one day enable fast and efficient discovery of new drugs for a variety of protease-linked diseases, thus improving lives of millions of patients around the world," said Turk.

SERS on a chip

SERS uses a metal surface with nanoscale roughness to enhance weak signals produced when light interacts with a sample. Because of its high sensitivity, the spectroscopy technique can detect analytes in extremely small volumes. Although SERS has been used for sensitive and selective detection of proteases, this has only been demonstrated using a bulky Raman microscopy setup.

Recently, nanoplasmonic slot waveguides have emerged as a new way to efficiently excite and collect SERS signals. These waveguides consist of two rails that form a small gap through which light can be guided. Coating the inside of the gap with gold nanostructures can be used to produce the SERS effect. Because of their small size, waveguides can be incorporated onto lab-on-a-chip devices, allowing simultaneous measurement of many analytes for high-throughput drug discovery.

To see if these nanoplasmonic slot waveguides would be useful for SERS detection of proteases, the researchers fabricated a waveguide and designed an experiment for detecting the trypsin protease. They created a specific peptide substrate for trypsin that binds to the gold nanostructure.



Credit: CC0 Public Domain

When the trypsin peptide cleaves to the substrate, part of the substrate diffuses away, creating a detectable reduction in intensity for the SERS spectrum.

Their experiment revealed a 70% decrease in SERS intensity after one hour of trypsin incubation, showing that nanoplasmonic slot waveguides could be used to detect trypsin. The researchers are now working to expand their platform so that it can detect the activity of two or more proteases simultaneously. The work was the collaboration between Ghent University-imec and the Flemish Institute for Biotechnology (VIB) under the supervision of Professors Roel Baets and Kris Gevaert.

More information: www.frontiersinoptics.com/home/
<https://phys.org/news/2020-09-waveguides-sensitive-protease.html>



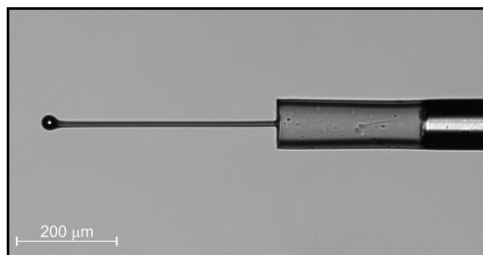
Wed, 09 Sept 2020

Researchers make tiny, yet complex fiber optic force sensor

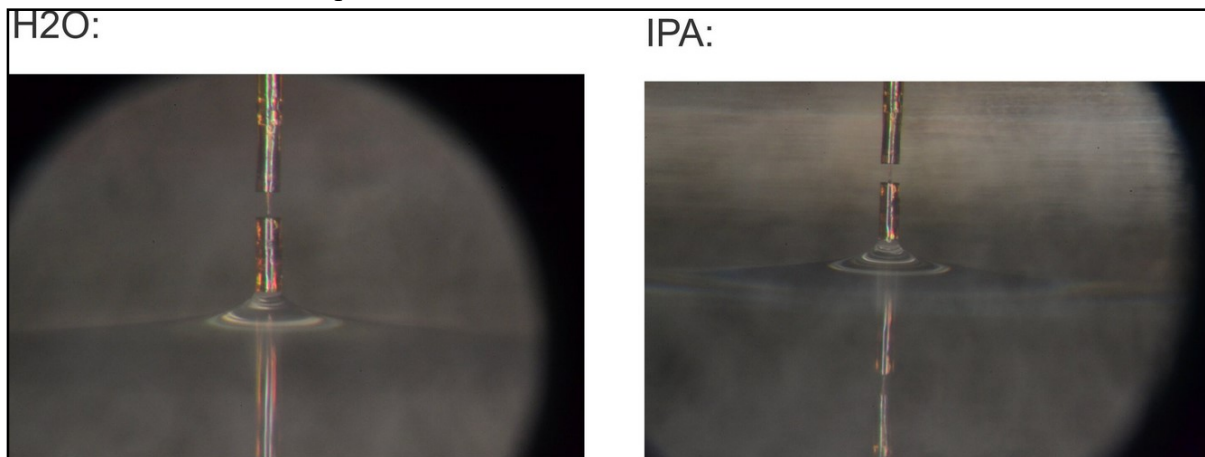
Researchers have developed a tiny fiber optic force sensor that can measure extremely slight forces exerted by small objects. The new light-based sensor overcomes the limitations of force sensors based on micro-electro-mechanical sensors (MEMS) and could be useful for applications from medical systems to manufacturing.

"Applications for force sensing are numerous, but there is a lack of thoroughly miniature and versatile force sensors that can perform force measurements on small objects," said research team leader Denis Donlagic from the University of Maribor in Slovenia. "Our sensor helps meet this need as one of the smallest and most versatile optical-fiber force sensors designed thus far."

In The Optical Society (OSA) journal *Optics Letters*, Donlagic and Simon Pevec describe their new sensor, which is made of silica glass formed into a cylinder just 800 microns long and 100 microns in diameter—roughly the same diameter as a human hair. They demonstrate the new sensor's ability to measure force with a resolution better than a micronewton by using it to measure the stiffness of a dandelion seed or the surface tension of a liquid.



Researchers developed a tiny fiber optic force sensor that can measure extremely slight forces exerted by small objects. It can be immersed in a variety of liquids and doesn't need any additional packaging for most applications. Credit: Denis Donlagic, U



The researchers used the new sensor to measure the surface tension of a liquid by measuring the retraction force when a miniature cylinder was removed from water (left) and isopropyl alcohol (right). Credit: Denis Donlagic, University of Maribor

"The high resolution force sensing and broad measuring range could be used for sensitive manipulation and machining of small objects, surface tension measurements on very small volumes of liquid, and manipulating or examining the mechanical properties of biological samples on the cellular level," said Donlagic.

Creating an all-glass sensor

Although MEMS-based sensors can provide miniature force sensing capabilities, their applications are limited because they require application-specific protective packaging and multiple electrical connections. Without proper packaging, MEMS devices also aren't biocompatible and can't be immersed in water.

To develop a more versatile miniature force sensor, the researchers created an all-optical fiber optic sensor completely made of glass. The complex undertaking was made possible by a special etching process the researchers had previously developed to create complicated all-fiber microstructures. They used this micromachining process to create a sensor based on a Fabry-Perot interferometer—an optical cavity made from two parallel reflecting surfaces.

The end of the sensor's lead-in fiber together with a thin flexible silica diaphragm were used to create the tiny interferometer. When external force is exerted onto a silica post with either a round or cylindrical force sensing probe on the end, it changes the length of the interferometer in a way that can be measured with subnanometer resolution.

The way the sensor's structures were fabricated created an air-sealed cavity that is protected from contamination and amenable for use in biochemical environments. Not only can it be immersed in a variety of liquids, but it can also measure positive and negative forces and doesn't need any additional packaging for most applications.

Measuring tiny forces

After evaluating and calibrating the sensor, the researchers used it to measure Young modulus—a measure of stiffness—of a human hair and common dandelion seed. They also measured surface tension of a liquid by measuring the retraction force when a miniature cylinder was removed from a liquid. The researchers were able to measure force with a resolution of about 0.6 micronewtons and a force range of about 0.6 millinewtons.

"The force sensing tip can be made substantially smaller—down to about 10 microns in diameter—and can be adapted to perform various force sensing tasks," said Donlagic. "The miniature force sensor can also be used to create more complex sensors such as sensors that measure magnetic and electric fields or determine the surface tension or flow of a liquid."

The researchers say that the current version of the sensor is ready for use. However, improving the overload robustness, producing probe tips with other shapes or adding miniaturized packaging could further expand potential applications. The researchers are also working to automate the processes used to fabricate the sensor to make it more practical.

More information: Simon Pevec et al, Miniature all-fiber force sensor, *Optics Letters* (2020). [DOI: 10.1364/OL.401690](https://doi.org/10.1364/OL.401690)

Journal information: *Optics Letters*
<https://phys.org/news/2020-09-tiny-complex-fiber-optic-sensor.html>

Physicists achieve tunable spin wave excitation

Physicists from MIPT and the Russian Quantum Center, joined by colleagues from Saratov State University and Michigan Technological University, have demonstrated new methods for controlling spin waves in nanostructured bismuth iron garnet films via short laser pulses. Presented in *Nano Letters*, the solution has potential for applications in energy-efficient information transfer and spin-based quantum computing.

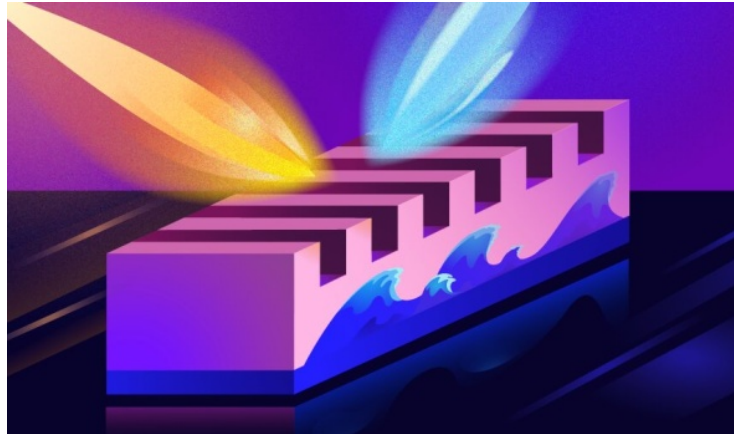
A particle's spin is its intrinsic angular momentum, which always has a direction. In magnetized materials, the spins all point in one direction. A local disruption of this magnetic order is accompanied by the propagation of spin waves, whose quanta are known as magnons.

Unlike the electrical current, spin wave propagation does not involve a transfer of matter. As a result, using magnons rather than electrons to transmit information leads to much smaller thermal losses. Data can be encoded in the phase or amplitude of a spin wave and processed via wave interference or nonlinear effects.

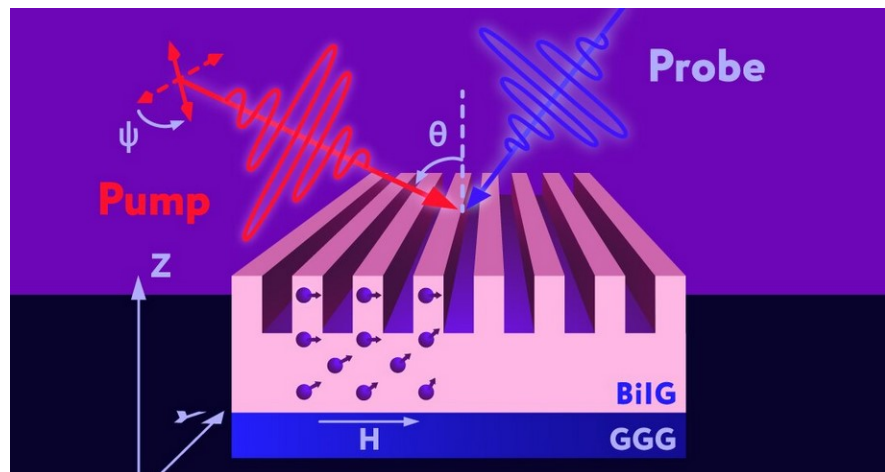
Simple logical components based on magnons are already available as sample devices. However, one of the challenges of implementing this new technology is the need to control certain spin wave parameters. In many regards, exciting magnons optically is more convenient than by other means, with one of the advantages presented in the recent paper in *Nano Letters*.

The researchers excited spin waves in a nanostructured bismuth iron garnet. Even without nanopatterning, that material has unique optomagnetic properties. It is characterized by low magnetic attenuation, allowing magnons to propagate over large distances even at room temperature. It is also highly optically transparent in the near infrared range and has a high Verdet constant.

The film used in the study had an elaborate structure: a smooth lower layer with a one-dimensional grating formed on top, with a 450-nanometer period. This geometry enables the excitation of magnons with a very specific spin distribution, which is not possible for an unmodified film.



Magnon excitation. Credit: Daria Sokol/MIPT



Schematic representation of spin wave excitation by optical pulses. The laser pump pulse generates magnons by locally disrupting the ordering of spins — shown as violet arrows — in bismuth iron garnet (BiIG). A probe pulse is then used to recover information about the excited magnons. GGG denotes gadolinium gallium garnet, which serves as the substrate Credit: Alexander Chernov et al./Nano Letters

To excite magnetization precession, the team used linearly polarized pump laser pulses, whose characteristics affected spin dynamics and the type of spin waves generated. Importantly, wave excitation resulted from optomagnetic rather than thermal effects.

The researchers relied on 250-femtosecond probe pulses to track the state of the sample and extract spin wave characteristics. A probe pulse can be directed to any point on the sample with a desired delay relative to the pump pulse. This yields information about the magnetization dynamics in a given point, which can be processed to determine the spin wave's spectral frequency, type, and other parameters.

Unlike the previously available methods, the new approach enables controlling the generated wave by varying several parameters of the laser pulse that excites it. In addition to that, the geometry of the nanostructured film allows the excitation center to be localized in a spot about 10 nanometers in size. The nanopattern also makes it possible to generate multiple distinct types of spin waves. The angle of incidence, the wavelength and polarization of the laser pulses enable the resonant excitation of the waveguide modes of the sample, which are determined by the nanostructure characteristics, so the type of spin waves excited can be controlled. It is possible for each of the characteristics associated with optical excitation to be varied independently to produce the desired effect.

"Nanophotonics opens up new possibilities in the area of ultrafast magnetism," said the study's co-author, Alexander Chernov, who heads the Magnetic Heterostructures and Spintronics Lab at MIPT. "The creation of practical applications will depend on being able to go beyond the submicrometer scale, increasing operation speed and the capacity for multitasking. We have shown a way to overcome these limitations by nanostructuring a magnetic material. We have successfully localized light in a spot few tens of nanometers across and effectively excited standing spin waves of various orders. This type of spin waves enables the devices operating at high frequencies, up to the terahertz range."

The paper experimentally demonstrates an improved launch efficiency and ability to control spin dynamics under optical excitation by short laser pulses in a specially designed nanopatterned film of bismuth iron garnet. It opens up new prospects for magnetic data processing and quantum computing based on coherent spin oscillations.

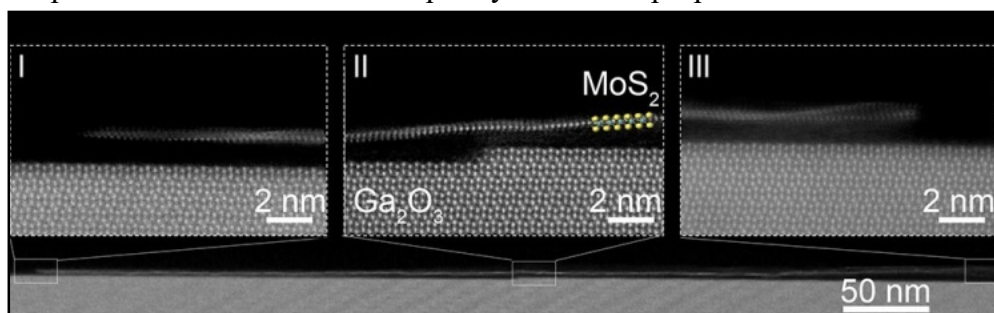
More information: Alexander I. Chernov et al. All-Dielectric Nanophotonics Enables Tunable Excitation of the Exchange Spin Waves, *Nano Letters* (2020). DOI: [10.1021/acs.nanolett.0c01528](https://doi.org/10.1021/acs.nanolett.0c01528)

Journal information: [Nano Letters](https://phys.org/news/2020-09-physicists-tunable.html)
<https://phys.org/news/2020-09-physicists-tunable.html>

Peel-apart surfaces drive transistors to the ledge

Semiconductor manufacturers are paying more attention to two-dimensional materials, such as transition metal dichalcogenides (TMDs), following the discovery, at KAUST, of an epitaxial growth process of single-crystal TMDs nanoribbons.

An emerging trend in transistor design involves space-saving architectures that stack components on top of one other. TMDs have potential for these systems because they readily form into thin sheets, known as nanoribbons, which have electrical, optical and magnetic activity. However, typical semiconductor processes, such as photolithography, require complicated procedures to produce TMDs of sufficient quality for device purposes.



This cross-section view shows the long and monolayer MoS₂ nanoribbon on top of the ledge of Ga₂O₃ substrate. Credit: 2020 KAUST

In collaboration with researchers in the U.S., Belgium and Taiwan, Vincent Tung and colleagues at KAUST are developing alternative approaches to TMD fabrication using surface templates to direct single-crystal growth.

While analyzing candidates with high-resolution electron microscopy, researcher Areej Aljarb spotted something unusual about a semiconductor named gallium trioxide (Ga₂O₃). After peeling off layers of the flaky material using sticky tape, she saw arrays of narrow, terrace-like ledges that stepped up or down the entire Ga₂O₃ surface.

"The steps are very steep and well-exposed," says Aljarb. "And because the atoms located near the vicinity of these ledges have asymmetric structures, they can drive growth in specific directions."

When the team exposed Ga₂O₃ surfaces to a mix of molybdenum and sulfur gas, they observed that TMD nanoribbons crystallized lengthwise along the ledges with structures that were practically defect free. Microscopy experiments and theoretical models revealed that the ledge atoms had unique energetic features that enabled aligned nucleation to form single-crystal nanoribbons. "For decades, scientists have sought to grow 2-D single-crystal semiconductors on insulators, and this work demonstrates that controlling the ledges of the substrate is the key," says Tung.

Intriguingly, the nanoribbons could be pulled off and transferred to other substrates without damaging them. To explore potential applications of the ledge-directed growth technology, the international group joined together to design a transistor capable of incorporating nanoribbons from the Ga₂O₃ template. Electronic measurements showed the new transistor could operate at high speeds and had amplification factors similar to TMD materials produced through more labor-intensive techniques.

"The nanoribbons grow along the ledges using weak physical interactions to stay in place, meaning that no chemical bonds form between the TMD and the underlying Ga₂O₃ substrate," notes Aljarb. "This unique feature enables us to transfer the nanoribbons onto foreign substrates for

many applications, ranging from transistors, sensors, artificial muscles and atomically thin photovoltaics."

More information: Areej Aljarb et al, Ledge-directed epitaxy of continuously self-aligned single-crystalline nanoribbons of transition metal dichalcogenides, *Nature Materials* (2020). DOI: [10.1038/s41563-020-0795-4](https://doi.org/10.1038/s41563-020-0795-4)

Journal information: *Nature Materials*

<https://phys.org/news/2020-09-peel-apart-surfaces-transistors-ledge.html>



Wed, 09 Sept 2020

Quantum light squeezes the noise out of microscopy signals

Researchers at the Department of Energy's Oak Ridge National Laboratory used quantum optics to advance state-of-the-art microscopy and illuminate a path to detecting material properties with greater sensitivity than is possible with traditional tools.

"We showed how to use squeezed light—a workhorse of quantum information science—as a practical resource for microscopy," said Ben Lawrie of ORNL's Materials Science and Technology Division, who led the research with Raphael Pooser of ORNL's Computational Sciences and Engineering Division. "We measured the displacement of an atomic force microscope microcantilever with sensitivity better than the standard quantum limit."

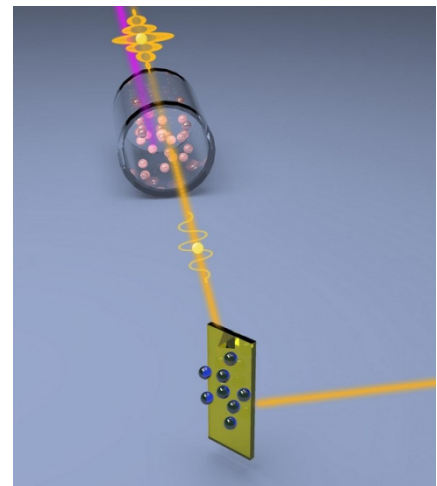
Unlike today's classical microscopes, Pooser and Lawrie's quantum microscope requires quantum theory to describe its sensitivity. The nonlinear amplifiers in ORNL's microscope generate a special quantum light source known as squeezed light.

"Imagine a blurry picture," Pooser said. "It's noisy and some fine details are hidden. Classical, noisy light prevents you from seeing those details. A 'squeezed' version is less blurry and reveals fine details that we couldn't see before because of the noise." He added, "We can use a squeezed light source instead of a laser to reduce the noise in our sensor readout."

The microcantilever of an atomic force microscope is a miniature diving board that methodically scans a sample and bends when it senses physical changes. With student interns Nick Savino, Emma Batson, Jeff Garcia and Jacob Beckey, Lawrie and Pooser showed that the quantum microscope they invented could measure the displacement of a microcantilever with 50% better sensitivity than is classically possible. For one-second long measurements, the quantum-enhanced sensitivity was 1.7 femtometers—about twice the diameter of a carbon nucleus.

"Squeezed light sources have been used to provide quantum-enhanced sensitivity for the detection of gravitational waves generated by black hole mergers," Pooser said. "Our work is helping to translate these quantum sensors from the cosmological scale to the nanoscale."

Their approach to quantum microscopy relies on control of waves of light. When waves combine, they can interfere constructively, meaning the amplitudes of peaks add to make the resulting wave bigger. Or they can interfere destructively, meaning trough amplitudes subtract



ORNL researchers developed a quantum, or squeezed, light approach for atomic force microscopy that enables measurement of signals otherwise buried by noise. Credit: Raphael Pooser, ORNL, U.S. Dept. of Energy

from peak amplitudes to make the resulting wave smaller. This effect can be seen in waves in a pond or in an electromagnetic wave of light like a laser.

"Interferometers split and then mix two light beams to measure small changes in phase that affect the interference of the two beams when they are recombined," Lawrie said. "We employed nonlinear interferometers, which use nonlinear optical amplifiers to do the splitting and mixing to achieve classically inaccessible sensitivity."

The interdisciplinary study, which is published in *Physical Review Letters*, is the first practical application of nonlinear interferometry.

A well-known aspect of quantum mechanics, the Heisenberg uncertainty principle, makes it impossible to define both the position and momentum of a particle with absolute certainty. A similar uncertainty relationship exists for the amplitude and phase of light.

That fact creates a problem for sensors that rely on classical light sources like lasers: The highest sensitivity they can achieve minimizes the Heisenberg uncertainty relationship with equal uncertainty in each variable. Squeezed light sources reduce the uncertainty in one variable while increasing the uncertainty in the other variable, thus "squeezing" the uncertainty distribution. For that reason, the scientific community has used squeezing to study phenomena both great and small.

The sensitivity in such quantum sensors is typically limited by optical losses. "Squeezed states are fragile quantum states," Pooser said. "In this experiment, we were able to circumvent the problem by exploiting properties of entanglement." Entanglement means independent objects behaving as one. Einstein called it "spooky action at a distance." In this case, the intensities of the light beams are correlated with each other at the quantum level.

"Because of entanglement, if we measure the power of one beam of light, it would allow us to predict the power of the other one without measuring it," he continued. "Because of entanglement, these measurements are less noisy, and that provides us with a higher signal to noise ratio."

ORNL's approach to quantum microscopy is broadly relevant to any optimized sensor that conventionally uses lasers for signal readout. "For instance, conventional interferometers could be replaced by nonlinear interferometry to achieve quantum-enhanced sensitivity for biochemical sensing, dark matter detection or the characterization of magnetic properties of materials," Lawrie said.

The title of the paper is "Truncated nonlinear interferometry for quantum enhanced atomic force microscopy."

More information: R. C. Pooser et al, Truncated Nonlinear Interferometry for Quantum-Enhanced Atomic Force Microscopy, *Physical Review Letters* (2020). DOI: [10.1103/PhysRevLett.124.230504](https://doi.org/10.1103/PhysRevLett.124.230504)

Journal information: [Physical Review Letters](https://phys.org/news/2020-09-quantum-noise-microscopy.html)
<https://phys.org/news/2020-09-quantum-noise-microscopy.html>

Boundaries no barrier for thermoelectricity

By Mike Williams

Though the Summer Olympics were postponed, there's at least one place to see agile hurdlers go for the gold.

You just need a way to view these electron games.

Using a novel optical detection system, researchers at Rice University found that electricity generated by temperature differences doesn't appear to be affected measurably by grain boundaries placed in its way in nanoscale gold wires, while strain and other defects in the material can change this "thermoelectric" response.

The phenomenon could allow for the detection of crystalline defects in conducting materials that are difficult to spot and characterize with even the most advanced microscopic methods.

The result was a surprise to researchers led by Rice physicist Doug Natelson and doctoral alumna Charlotte Evans, now a staff scientist at Sandia National Laboratories, who pursued the explanation after seeing measurements they couldn't explain a few years ago.

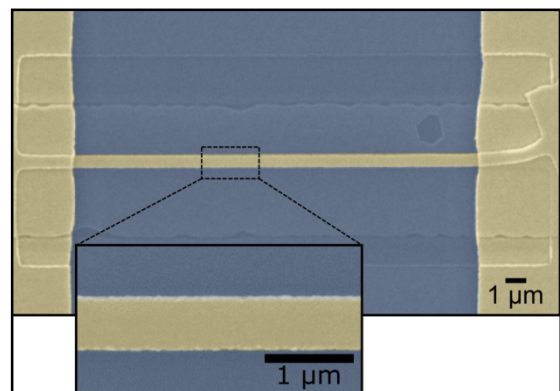
"A lot of times, people think about the thermoelectric effect when they're building solar panels or generating power from this or that," Evans said. "We argue instead that the thermoelectric effect is a really interesting diagnostic tool."

The study appears in the *Proceedings of the National Academy of Sciences*.

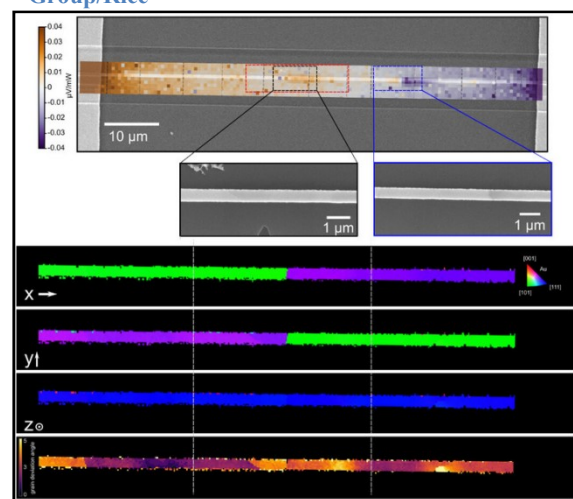
Grain boundaries are the planes in materials where misaligned crystals meet, forcing atoms along the edge to adjust as they bind to their neighbors. Measurements in bi-crystal gold nanowires produced by the group of Stanford University electrical engineer and co-author Jonathan Fan showed no detectable effect on thermoelectric voltages at the grain boundary—the electrons in the metal simply ignored the single grain boundary.

Temperature differences in conductors create thermoelectricity through the Seebeck effect, one type of thermoelectric effect. This effect is commonly used to measure temperature differences and to control thermostats. The Natelson lab triggered the Seebeck effect by heating one portion

of Fan's wires with a tightly controlled laser, driving electrons to move from the hot location toward colder regions, and produced a voltage to be measured. No measurable change in the voltage was seen when the laser was moved across the grain boundary in the bi-crystals.



A scanning electron microscope image shows a single-crystal gold nanowire on a thermal oxide substrate. Rice University scientists showed that strain and defects in the material can change its thermoelectric response. Credit: Natelson Research Group/Rice



Rice University's optical detection system reveals small structural defects in a gold nanowire that may appear to be a perfect crystal under a scanning electron microscope. The discovery has implications for making better thin-film electronic devices. Cr

When the laser was moved across parts of the same wires that were deformed, with distortions in the crystal lattice throughout the wire, changes in the voltage became apparent, Natelson said. Annealing the distorted devices partly healed the defects, resulting in clear changes in the thermoelectric current.

"There's a community of people who play around with improving thermoelectric response," Natelson said. "They need to be aware that structural issues like very small distortions to the lattice have effects that are not necessarily small. People tend to ignore these tiny structural issues, but anytime you're making thin-film devices, there's baked-in stress and strain in the material, just because of the way it's made."

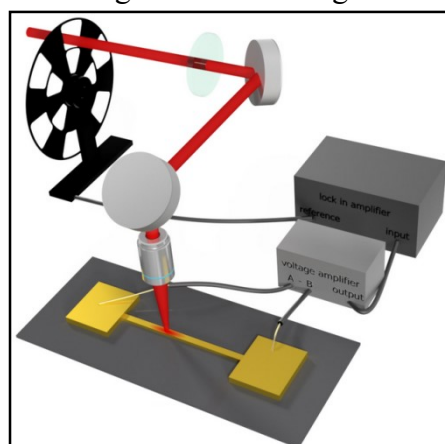
Evans said nanoscale crystals are often characterized via electron backscatter diffraction (EBSD), an expensive and time-consuming process. "The benefit of our process is its simplicity," she said. "We use a large spot size from a laser, two microns, which is much larger than the size of an e-beam, and we can detect variations using just a lock-in technique, a scanning laser and a voltage amplifier.

"If you look at the plain EBSD data, it looks as though you have a pristine crystal," she said. "And it's not until you post-process the data and look at how each pixel varies from the next that you would see small distortions along the length of the wire. It's complicated to detect. That's why it's so remarkable that we could detect these little variations with a laser."

"So if you want to do something clever and exploit the thermoelectric response, you need to understand the devices you're making with standard, top-down fabrication methods," Natelson said. "The stress and strain and what seemed like minor structural imperfections can have an easily detectable influence."

More information: Charlotte I. Evans et al. Thermoelectric response from grain boundaries and lattice distortions in crystalline gold devices, *PNAS*. September 8, 2020 doi.org/10.1073/pnas.2002284117

Journal information: [Proceedings of the National Academy of Sciences](https://phys.org/news/2020-09-boundaries-barrier-thermoelectricity.html)
<https://phys.org/news/2020-09-boundaries-barrier-thermoelectricity.html>



Using a novel optical detection system that heats nanoscale gold wires with a single laser, researchers at Rice University showed electricity generated by temperature differences is not affected measurably by grain boundaries, while strain and other defe

Scientists develop low-cost chip to detect presence and quantity of COVID-19 antibodies

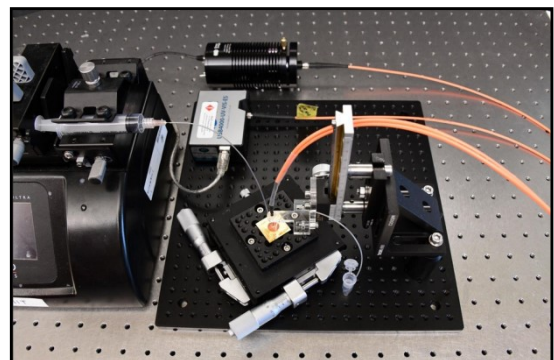
Robust and widespread antibody testing has emerged as a key strategy in the fight against SARS-CoV-2, the virus responsible for the COVID-19 pandemic. However current testing methods are too inaccurate or too expensive to be feasible on a global scale. But now, scientists at the Okinawa Institute of Science and Technology Graduate University (OIST) have developed a rapid, reliable and low-cost antibody test.

The device, described in a proof-of-concept study published this week in *Biosensors and Bioelectronics*, uses portable lab-on-a-chip technology to accurately measure the concentration of antibodies present in diluted blood plasma.

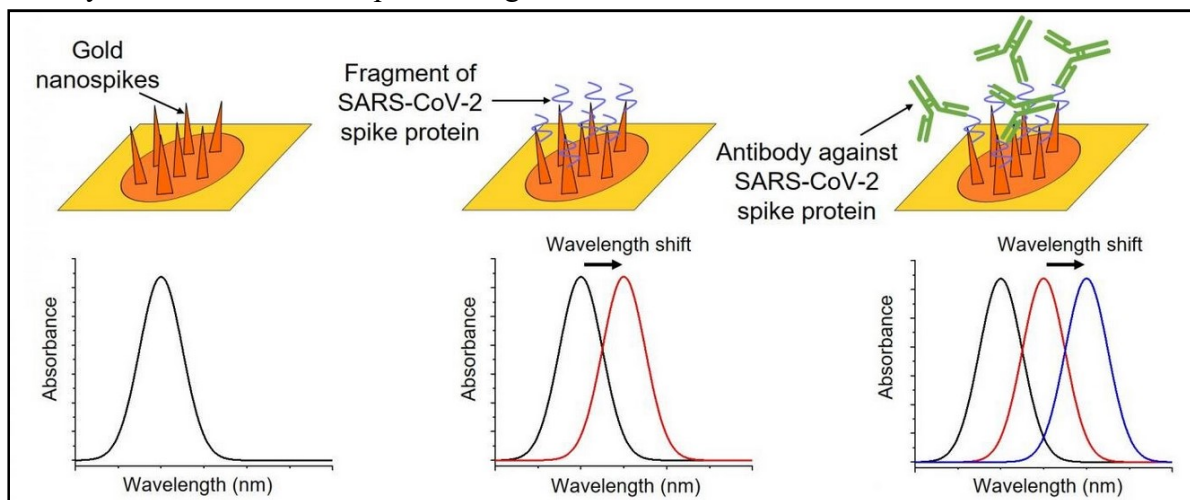
Antibodies are proteins produced by the immune system to neutralize the virus. Research has found that COVID-19 antibodies are present in the later stages of infection and can linger in the blood after the infection has cleared, allowing previously infected individuals to be identified. Antibody tests are thus an important means of determining the full spread of the coronavirus—information that is crucial to guide public health policies.

And yet many nations have so far failed to employ large-scale antibody testing.

"Many existing platforms for antibody tests are accurate and reliable, but they are costly and need to be carried out in a lab by trained operators. This means that it can take hours, or even days, to obtain results," said Dr. Riccardo Funari, first author and postdoctoral researcher in the Micro/Bio/Nanofluidics Unit at OIST. "Other tests are easier to use, portable and rapid, but are not sufficiently accurate, which hampers testing efforts."



The antibody testing platform, developed by researchers from the Micro/Bio/Nanofluidics Unit at OIST. Credit: OIST



The researchers avoided this trade-off between accuracy and accessibility by developing an alternative antibody testing platform that combines a powerful light-sensing technology with a

microfluidic chip. The chip provides results within 30 minutes and is highly sensitive, detecting even the lowest clinically-relevant antibody concentration. Each chip is cheap to manufacture and negates the need for a lab or trained operators, increasing the feasibility of nation-wide testing.

And there's another distinctive advantage of this newly developed platform. "The test doesn't just detect whether the antibodies are present or absent—it also provides information about the quantity of antibodies produced by the immune system. In other words, it's quantitative," said Professor Amy Shen, who leads the Micro/Bio/Nanofluidics Unit. "This greatly expands its potential applications, from

treating COVID-19 to use in developing vaccines."

Illuminating the antibodies

The antibody testing platform consists of a microfluidic chip which is integrated with a fiber optic light probe. The chip itself is made from a gold-covered glass slide with an embedded microfluidic channel. Using an electric voltage, the team fabricated tens of thousands of tiny spiky gold structures, each one smaller than the wavelength of light, on a glass slide.

The researchers then modified these gold nanospikes by attaching a fragment of the SARS-CoV-2 spike protein. This protein is crucial for helping the coronavirus infect cells and causes a strong reaction from an infected person's immune system.

In this proof-of concept study, the scientists demonstrated the principle behind how the test detects antibodies by using artificial human plasma sample spiked with COVID-19 antibodies that are specific to the spike protein.

Using a syringe pump, the sample is drawn through the chip. As the plasma flows past the protein-coated gold nanospikes, the antibodies bind to the spike protein fragments. This binding event is then detected by the fiber optic light probe.

"The detection principle is simple but powerful," said Dr. Funari. He explained that it is based on the unique behavior of electrons on the surface of the gold nanospikes, which oscillate together when hit by light. These resonating electrons are highly sensitive to changes in the surrounding environment, such as the binding of antibodies, which causes a shift in the wavelength of light absorbed by the nanospikes.

"The more antibodies that bind, the larger the shift in the wavelength of the absorbed light," added Dr. Funari. "The fiber optic probe is connected to a light detector which measures this shift. Using that information, we can determine the concentration of antibodies within the plasma sample."

A bright future

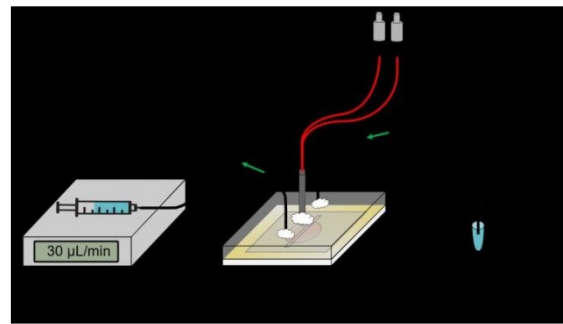
The large-scale roll-out of a quantitative test could greatly impact how COVID-19 is treated.

For example, quantitative tests could help doctors track how effectively a patient's immune system is fighting the virus. It could also be used to help identify suitable donors for a promising experimental treatment, called plasma transfusion therapy, where a recovered patient's antibody-rich blood is donated to currently infected patients to help them fight the virus.

Being able to measure the level of immune response can also aid vaccine development, allowing researchers to determine how effectively a trial vaccine triggers the immune system.

However, the researchers emphasized that the device is still undergoing active development. The unit aims to reduce the chip size to cut manufacturing costs and is also working on improving the reliability of the test.

"We have shown that the device works to detect different concentrations of the spike protein antibody in artificial human plasma samples. We now want to expand the test so that the chip can detect multiple different antibodies at the same time," said Dr. Funari. "Once the device is



The green arrows show the direction that the sample moves through the chip, due to the action of the syringe pump. Credit: OIST

optimized, we plan to collaborate with local hospitals and medical institutions to perform tests on real patient samples."

More information: Riccardo Funari et al, Detection of antibodies against SARS-CoV-2 spike protein by gold nanospikes in an opto-microfluidic chip, *Biosensors and Bioelectronics* (2020). DOI: [10.1016/j.bios.2020.112578](https://doi.org/10.1016/j.bios.2020.112578)

Journal information: *Biosensors and Bioelectronics*
<https://phys.org/news/2020-09-scientists-low-cost-chip-presence-quantity.html>



Wed, 09 Sept 2020

Real-time imaging shows how SARS-CoV-2 attacks human cells

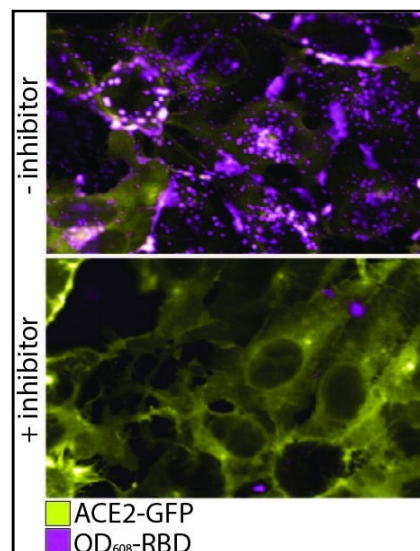
By Anna Demming

"What we're doing here is actually visualizing binding of the spike to ACE 2 [angiotensin converting enzyme 2]," says Kirill Gorshkov a research scientist at the National Center for Advancing Translational Sciences (NCATS) in Maryland, U.S.

Innocuous though this may sound to the uninitiated, this binding is the first step in a process of viral proliferation that may have led to the worst pandemic in living memory. The "spike" is a protein on the SARS-CoV-2 virus that is widely recognized as the primary weapon of attack for mobilizing its viral DNA into a host cell. The ACE2 receptors are human cell proteins that effectively open the door for this attack. Using bioengineered quantum dots, Gorshkov and Eunkeu Oh at the Naval Research Laboratory (NRL) in Washington, D.C., and their colleagues were able to image the binding and subsequent internalization that takes place when ACE2 and the spike protein interact. "You can actually see that happen in real time," adds Gorshkov, "That's the beauty of this assay and that's why we think it will be important for drug screening."

A virus cannot reproduce without enrolling a host cell, so researchers around the globe have been working to understand how SARS-CoV-2 interacts with and penetrates cells with the aim of blocking this stage and preventing the onset of COVID19. Gorshkov and his colleagues at NCATS were already working on various imaging assays for cancers, viruses and lysosomal storage diseases, "but when coronavirus hit, we quickly had to shift gears," says Gorshkov.

Prior SARS research had highlighted the importance of interactions with ACE2 in human cells for the spread of this kind of virus, and they were already able to tag these receptor proteins with a green fluorescent protein to image their movements. Evidence was also accumulating to pinpoint the specific spike proteins on SARS-CoV-2 that might be locking ACE2 into a stronghold so that the virus can enter the cell. However, information on spike protein interactions has mostly accrued indirectly from biochemical or proximity assays and tests with proteins and parts of proteins taken from the virus—"pseudo-viro-particles." With no fluorescent labeling of these viral proteins, their role in the ACE2 receptor binding and subsequent internalization—endocytosis—continued to play out effectively under cover of darkness to imaging.



QD608-RBD binds ACE2 and induces endocytosis. In this figure, the top panel shows ACE2-GFP (yellow) expressing cells binding and internalizing QD608-RBD (magenta). In the bottom panel, an inhibitor is added to prevent binding of QD608-RBD to ACE2-GFP, and the presence of ACE2-GFP on the cell surface is strong with little to no QD608-RBD visible. Credit: NCATS

At NRL, researchers were also keen to leverage their expertise with nanoparticles for cellular delivery and biosensing to help efforts in search of anti-COVID19 drugs. Oh began looking into possible ways of applying the protein-nanostructure conjugation techniques she had been working with for over 15 years. With two proteins that share a binding affinity—a quantum dot attached to one and a fluorescing nanoparticle attached to the other—binding between the two proteins will then bring the nanostructures close enough for energy transfer between them.

The resulting fluorescence quenching then allows the researchers to monitor the protein binding. "If you have any inhibitor in the middle to stop the binding, this can be used as an inhibition assay for drug screening, so we use this a lot," explains Oh. Seeing the potential application for screening antibodies against COVID19, Oh and her team led by Mason Wolak presented their ideas to the team at NCATS, and the two institutions set straight to work to develop it further.

Developing a "pseudovirion"

The first step from Oh's side of the collaboration was to develop a "pseudovirion" with the potent parts of SARS-CoV-2 spike proteins (where the receptor binding domain is situated) attached to the quantum dot in such a way that the spike proteins continue to attack and penetrate cells just like an active virus. For this, the orientation of the spike proteins and the shape of the pseudovirion was key, and here, Oh's extensive experience conjugating active proteins to nanostructures paid off. Before moving on to the more expensive cellular delivery tests, they had to test whether their pseudovirion was functioning outside of cells by conjugating fluorescing gold nanoparticles to the ACE2 receptors and monitoring for fluorescence quenching. Oh lists the multiple ratios of protein to quantum dot, quantum dot sizes and surface chemistries they tried before they were finally able to observe fluorescence quenching on protein binding, and were ready to send the pseudovirion to Gorshkov's team "to do cool stuff with the real cell."

To observe the pseudovirion interacting with ACE2 in a real cell, the quantum dot on the pseudovirion now needed to be engineered to emit at a wavelength that was easy to distinguish from the green fluorescent protein on ACE2, as opposed to optimizing nanoparticle quenching. With the two clear signals, the team at NCATS could track the binding of the two proteins and subsequent endocytosis. Additionally, they could see that the binding and endocytosis was prevented in the presence of two test antibodies. They could even test the endocytosis mechanism, which proceeds by means of a protein named dynamin. When they added Dyngo-4a, which interrupts dynamin, they could see the binding take place but no subsequent endocytosis.

The results also chalk up a success for remote research collaborations, as the teams never actually met. "The type of collaboration we have here is a rare one," says Gorshkov, reflecting how much their progress outpaced previous collaborations where there had been a greater number of physical meetings and coordinated activities. "There was such a drive and such a focus from both groups that it really synergised very well."

The quantum dot pseudovirion is limited to imaging cell penetration by endocytosis, and it remains to be determined whether this mechanism comes into force for all cell types, lung tissue in particular. An alternative SARS-CoV-2 attack mechanism is based on membrane fusion, and imaging this with the quantum-dot pseudovirion would require significant modifications to interact with the cell more like a membrane. However, the fast throughput and direct observations the quantum-dot pseudovirion enables should pose significant advantages in the search for antibodies.

More information: Kirill Gorshkov et al. Quantum-Dot-Conjugated SARS-CoV-2 Spike Pseudovirions Enable Tracking of Angiotensin Converting Enzyme 2 Binding and Endocytosis, *ACS Nano* (2020). DOI: [10.1021/acsnano.0c05975](https://doi.org/10.1021/acsnano.0c05975)

Journal information: [ACS Nano](https://doi.org/10.1021/acsnano.0c05975)

<https://phys.org/news/2020-09-real-time-imaging-sars-cov-human-cells.html>

Restoring the filtration efficiency of N95 masks after they have been cleaned

N95 masks are a critical part of the personal protective equipment used by front-line health care workers. These masks achieve 95% efficiency at filtering out tiny 0.3-micron particles, while maintaining reasonable breathability, thanks to a layer of fine melt-blown polypropylene fibers incorporating electrical charges to attract particles.

Extended usage and decontamination provoked by severe supply shortages around the globe during the COVID-19 pandemic can easily remove the charges and degrade filtration efficiency.

In the journal *Physics of Fluids*, researchers from India's Tata Institute of Fundamental Research and Israel's Technion-IIT share a method to restore the filtration efficiency of N95 masks to out-of-box levels—as long as the mask is not structurally compromised.

"Today, N95 masks are being worn by health care workers for extended periods," said co-author Shankar Ghosh. "This gives rise to very humid conditions, and humidity is detrimental to electrostatics."

During use, all electrostatics-based masks slowly lose their efficiency due to humidity.

"It's much worse in a place like Mumbai during the Indian monsoon, where ambient humidity levels can reach more than 90%," Ghosh said.

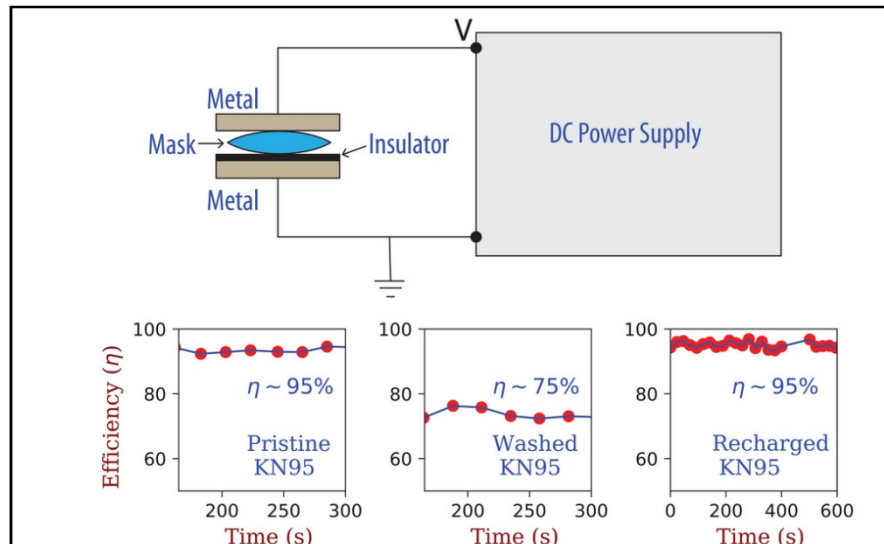
The group's work exploits that, under high electric fields, the polypropylene conductivity is high, which makes introducing excess charges into the material possible by connecting it to a battery. When the charge source is switched off, the applied electrical field becomes zero, and the conductivity of the polypropylene drops effectively to zero. As a result, the added charge carriers immobilize, and the material remains charged.

The researchers discovered they could toss an N95 into a standard washing machine to clean it, which significantly reduces its filtration efficiency. They could then recharge it by sandwiching it between two electrodes at high voltage to recover its 95% efficiency.

"We've also shown a proof-of-concept construction of a battery-operated smart mask, where the lost charge gets replenished periodically by plugging the mask into a charging station—akin to how you would charge your smartphone," Ghosh said.

The group believes its method to keep masks charged will lead to highly energy-efficient smart masks.

"Currents are in microamps, and the power requirement is extremely low, on the order of a milliwatt, so a compact and practical solution may soon be feasible," said Ghosh.



Schematic of the method to recharge decontaminated masks, and a comparison of their pristine, decontaminated and recharged filtration efficiencies. Credit: Tata Institute of Fundamental Research

Beyond this, their method will be useful for a variety of air filtration applications, such as HVAC or industrial filters.

More information: "Recharging and rejuvenation of decontaminated N95 masks," *Physics of Fluids*, aip.scitation.org/doi/10.1063/5.0023940

Journal information: *Physics of Fluids*
<https://phys.org/news/2020-09-filtration-efficiency-n95-masks.html>



Wed, 09 Sept 2020

In high-risk patients, study shows how Covid impairs immune activity

A protein called PD-1 is known to act as a molecular 'brake' on the immune system.

It regulates the immune response so as to prevent the immune system attacking the body

Why are older people and people with underlying conditions at particular risk of severe Covid-19? New research has identified a possible reason: While these risk groups produce greater quantities of the immune cell known as 'T-helper cells', their T-helper cells show impaired function. The study, by researchers from Charité – Universitätsmedizin Berlin, is published in the *Journal of Clinical Investigation*.

The researchers collected blood samples from 39 Covid-19 patients admitted to Charité. From these blood samples, they isolated immune cells and stimulated these with fragments of the SARS-CoV-2 virus. The researchers then counted T-helper cells that had reacted to the viral fragments. Finally, they analysed whether there might be a link between the number of activated T-helper cells and the patients' risk factors.

Indeed, the researchers were able to show a correlation between the frequency of virus-specific T-helper cells and the patients' age. The same positive correlation was also found in relation to the 'Comorbidity Index', a measure expressing the severity of 19 different underlying medical conditions. The higher the patient's Comorbidity Index, the higher the number of SARS-CoV-2-specific T-helper cells in their blood.

The team also found, however, that advancing age and overall comorbidity scores were linked to a decrease in the proportion of cells producing an important messenger molecule. This stimulates other components of the immune response. In patients with risk factors, some of the SARS-CoV-2-specific T cells no longer function properly, the research found. "One might say that these T-helper cells are being slowed down in people with risk factors. We believe this has the potential to hamper the body's ability to mount an effective response against the pathogen," leading co-first author Dr Arne Sattler said in a statement.



The researchers collected blood samples from 39 Covid-19 patients admitted to Charité. From these blood samples, they isolated immune cells and stimulated these with fragments of the SARS-CoV-2 virus.

A protein called PD-1 is known to act as a molecular 'brake' on the immune system. It regulates the immune response so as to prevent the immune system attacking the body. The researchers showed that the virus-specific T-helper cells produced more PD-1 in patients with acute infection, than in those with milder symptoms.

Given that PD-1 could be partly responsible for the immune system in some people producing insufficient quantities of messenger substances, the researchers suggested that PD-1 be used as a new treatment target in patients with severe Covid-19. "Covid-19 patients may... benefit from

treatments which aim to release this type of 'immune system brake'. However, many more studies will be needed in order to clarify this matter," Dr Sattler said.

<https://indianexpress.com/article/explained/in-high-risk-patients-study-shows-how-covid-impairs-immune-activity-6588491/>



Wed, 09 Sept 2020

Plasma therapy didn't help reduce COVID-19 deaths: Top medical body study

The top medical research has made these revelations to investigate the effectiveness of plasma therapy for the treatment of COVID-19 after conducting a study in 39 hospitals across India

New Delhi: The Convalescent Plasma (CP) therapy didn't help in reducing death due to the coronavirus, the India Council of Medical Research (ICMR) revealed in a study.

The top medical research has made these revelations to investigate the effectiveness of plasma therapy for the treatment of COVID-19 after conducting a study in 39 hospitals across India.

For this, the ICMR researchers did an open-label, parallel-arm, phase II, multicentre, and randomized controlled trial from April 22 to July 14 this year. The trial was registered with the Clinical Trial Registry of India (CTRI) for the purpose, it said.

1,210 patients (moderately ill, confirmed COVID-19 cases) admitted across 39 trial sites were screened. Of these, 29 were teaching public hospitals and 10 were private hospitals spread across 14 states and Union Territories representing 25 cities.

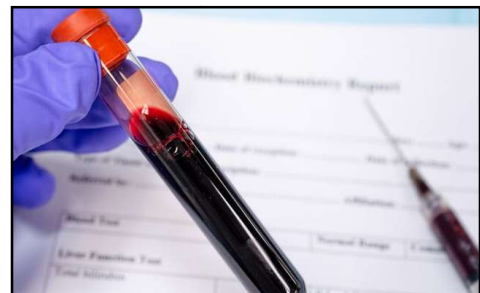
The study was conducted on 464 randomly enrolled participants who were hospitalized and were moderately ill, confirmed COVID-19 patients. 235 participants were put in the intervention arm while 229 subjects were in the control arm.

According to the study, participants were randomised to either the control or the intervention arm. Two doses of 200 ml CP was transfused 24 hours apart in the intervention arm.

"Composite primary outcome was achieved in 44 (18.7 per cent) participants in the intervention arm and 41 (17.9 per cent) in the control arm. Mortality was documented in 34 (13.6 per cent) and 31 (14.6 per cent) participants in intervention and control arm, respectively," the study mentioned.

"Convalescent Plasma was not associated with a reduction in mortality or progression to severe COVID-19. This trial has high generalisability and approximates real-life setting of convalescent plasma therapy in settings with limited laboratory capacity. A prior measurement of neutralizing antibody titres in donors and participants may further clarify the role of CP in the management of COVID-19," concluded the findings of the study.

<https://www.ndtv.com/india-news/convalescent-plasma-therapy-didnt-help-reduce-covid-19-deaths-top-medical-body-icmr-study-2292543>



The study was conducted on 464 randomly enrolled (Representational)

New research: Radiologists show how chest X-rays can predict Covid-19

Researchers have found that chest C-rays could aid in rapid diagnosis of Covid-19. Their findings are published in Radiology: Cardiothoracic Imaging

New Delhi: Researchers have found that chest C-rays could aid in rapid diagnosis of Covid-19. Their findings are published in Radiology: Cardiothoracic Imaging.

Radiologists at Louisiana State University Health Sciences Center (LSU Health) New Orleans conducted a retrospective study of nearly 400 persons under investigation for Covid-19 in New Orleans. They reviewed the patients' chest X-rays along with concurrent RT-PCR virus tests. Using Covid-19 imaging patterns, they categorised each chest X-ray as characteristic, nonspecific, or negative in appearance for Covid-19.

The radiologists found a characteristic chest X-ray appearance is highly specific (96.6 per cent) and has a high positive predictive value of 83.3 per cent for SARS-CoV-2 infection in the setting of pandemic.

<https://indianexpress.com/article/explained/radiologists-show-how-chest-x-rays-can-predict-covid-19-6587724/>



Using Covid-19 imaging patterns, they categorised each chest X-ray as characteristic, nonspecific, or negative in appearance for Covid-19. (Representational Image)

Russia releases first batch of Covid-19 vaccine Sputnik V into public

The Russian health ministry registered the first vaccine against Covid-19, named Sputnik V, on August 11

Moscow: The first batch of the Sputnik V vaccine against Covid-19, developed by Russia's Gamaleya National Research Center of Epidemiology and Microbiology and the Russian Direct Investment Fund (RDIF) has been released into civil circulation, regional deliveries are planned in the nearest future, the Russian health ministry informs.

"The first batch of the 'Gam-COVID-Vac' [Sputnik V] vaccine for the prevention of the new coronavirus infection, developed by the Gamaleya National Research Center of Epidemiology and Microbiology of the Ministry of Health of Russia, has passed the necessary quality tests in the laboratories of Roszdravnadzor [medical device regulator] and has been released into civil circulation," the ministry said in a statement. The Russian health ministry registered the first vaccine against Covid-19, named Sputnik V, on August 11.

Moscow Mayor Sergey Sobyenin expressed hope on Sunday that the majority of the Russian capital's residents would be vaccinated against the coronavirus within several months.

According to the health ministry, the delivery of the first batches of the Russian vaccine to the country's regions is planned in the nearest future.

<https://www.hindustantimes.com/world-news/russia-releases-first-batch-of-covid-19-vaccine-sputnik-v-into-public/story-3zo0QMVHlwEu0EGQgrjS5L.html>

