A microscopic view of several red blood cells, rendered in a vibrant red color. The cells are biconcave and have a textured surface. They are arranged in a cluster, with some in the foreground and others in the background, creating a sense of depth. The background is a soft, out-of-focus red.

FROM MICRO-OBJECTS TO MEDICAL DIAGNOSIS:

Exploring the Versatile Microscopic Gripper

Author: **Diogo Barradas**

Technology is moving to places the naked eye can't see. Miniaturisation is the process of reducing the size while increasing the efficiency of technology. A team of researchers from the University of Malta is developing a microscopic device which can manipulate minute objects, such as micro-objects and even singular cells!

Nineties children might remember *The Magic School Bus*, an iconic cartoon centred around the adventures of Ms Frizzle, an elementary school teacher, and her class of students aboard the Magic School Bus, capable of flying, shrinking, and travelling through space and time for the sake of science education. In one of its many well-known episodes, the class swims through an ailing student's bloodstream to diagnose their sore throat.

In the real world, we are not quite ready to send shrunken-down school buses into our veins to diagnose health queries. Science hasn't been able to keep up with that fantasy. Despite that inconvenience, it's possible that diagnosing ailments using microscopic technology (the quintessential concept behind that episode of *The Magic School Bus*) is not too far in the future.

We are approaching a golden age in micro and nanoelectromechanical system development: tiny devices that can be useful within various biomedical applications. Among them, a UM project aims to develop small-scale devices capable of diagnosing diseases in red blood cells, amongst other uses.

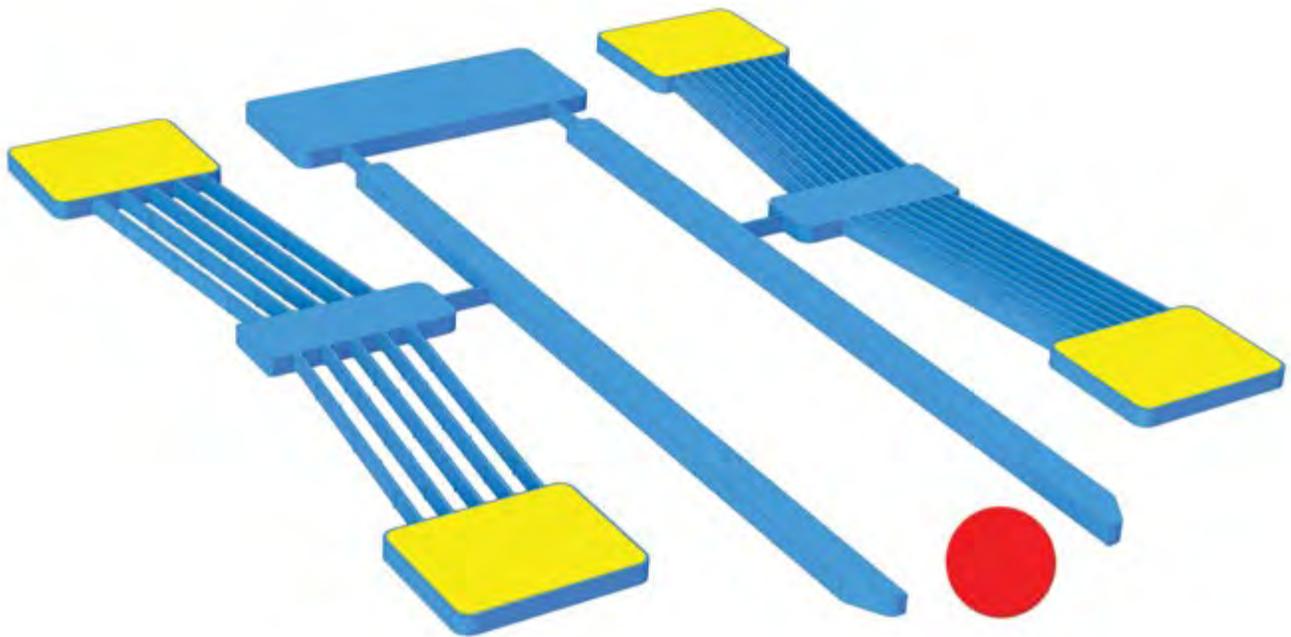
Ing. Thomas Sciberras from UM's Department of Mechanical Engineering is leading the development of the MEMSGRIP (micro-electromechanical system gripper) project in partnership with the Faculty of Information and Communications Technology. Along with Prof. Ivan Grech from the Department of Microelectronics, Prof. Ing. Pierluigi Mollicone from the Department of Mechanical Engineering, and other team members, his objective is to produce small gripping devices capable of clenching minute objects like red blood cells or micro-objects, such as calibration microspheres, MEMS chipllets, and

micron-size gears. The project is still in its development phase, but its prospects are promising.

SIZE MATTERS: MICROSCALE OBJECTS AND THE CHALLENGE OF MANIPULATION

'The aim of the project is essentially to design and develop a micro-electromechanical system (MEMS) device that can be used to manipulate soft, temperature sensitive micro-objects, such as red blood cells, whose diameter is down to between eight to twelve microns', explains Sciberras. Scale is a key factor here: one thousand microns corresponds to a mere millimetre.

Researchers work with 10-micron diameter probes/needles to provide electrical power to the devices with the help of a microscope. This delicate work is made even more challenging as researchers are working with biological



objects. Red blood cells, for example, need to be kept in specific conditions throughout the whole process. 'If we're going to analyse red blood cells, they need to be submerged in a particular fluid, which is typically a 0.9% sodium chloride solution,' details Sciberras, 'on the other hand, the temperature of the MEMS gripper device cannot exceed 37°C, which is essentially the body temperature of a healthy human being.' These requisites ensure that the cells keep their physical properties long enough to be characterised, which is vital to reach a diagnosis.

By applying pressure on the red blood cells, doctors are able to extract important data about the cell's physical properties. 'Certain pathological conditions, like sickle cell anaemia and type 2 diabetes, make red blood cells harder to compress, for example,' explains Sciberras.

'With a micro-electromechanical gripper type of system, the health professional will be able to access a red blood cell's properties by squashing one of its ends with a beam against a sensor, to measure the force that is coming through this squashing effect,' he continues.

Similar microscopic technology is not limited to the realm of medical sciences. Another potential use of the MEMS gripper is in micro-assembly, a relatively new field of work which handles and produces technological components on a microscale, such as in nano devices and robots. With minor tweaks, such as replacing the beam with a tweezer-like structure, the gripper could be incorporated into a micropositioner (something to move it around) to grab and assemble objects, such as nano devices. Essentially, it would work as a very small pair of nimble human fingers.

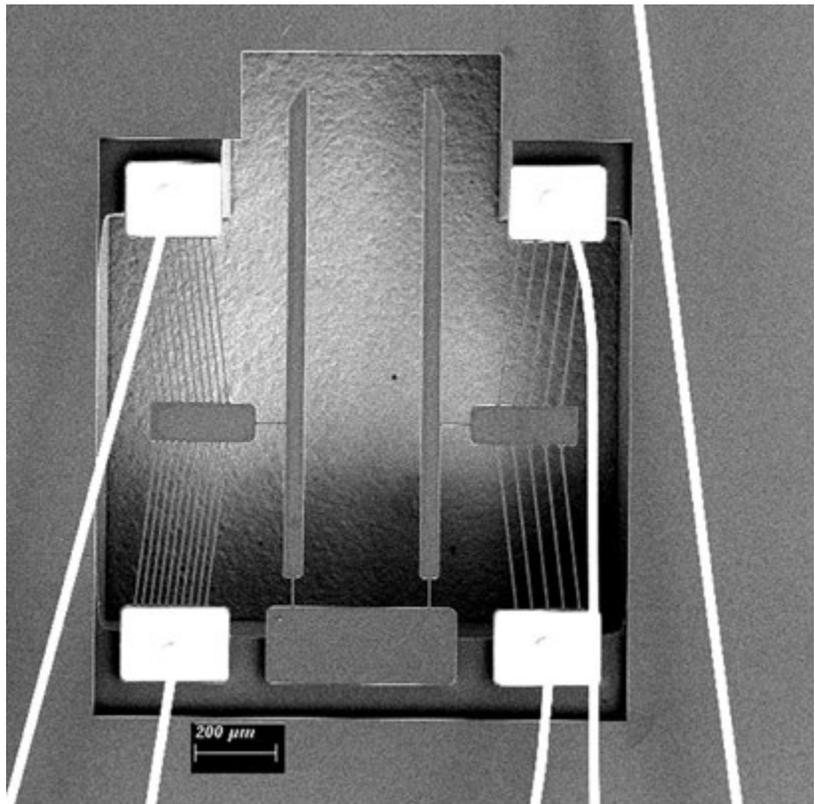
SIMULATIONS AND TESTING: PROGRESS AND FUTURE STEPS FOR THE MEMS GRIPPER

The MEMS gripper itself is made from doped (silicon with the intentional introduction of impurities, which allows it to act as a semiconductor). A semiconductor is a type of material that falls between conductors such as metal, which can easily carry electricity, and insulators, where electricity can't flow freely. When an electrical current is drawn through a semiconductor, heat is generated as a result. This heat has a role to play in how this MEMS gripper works. 'With the increase in temperature, you get thermal expansion,' points out Sciberras, 'If we carefully design the device in a particular way, the thermal expansion [caused by electricity

Left: CAD image with an illustration of a micro-object that shall be grasped by a typical MEMS. The yellow markings are a thin gold layer which allows for electrical conductivity and corrosion resistance, while the blue part is the semi-conductor, made from doped silicon.

Right: Scanning electron micrograph of the same device with a scale (200 μm).

Photos courtesy of Thomas Sciberras



passing through it] will enable it to move in the intended direction.'

Although still in development, the MEMS gripper has already had promising results in simulations. However, it has yet to undergo a full testing phase – which should happen in the next stage of the process.

Developing such a device is quite costly. The project team resorted to sharing a slice of silicon, called a wafer, with other projects from other researchers. This is a common practice, known as a multi-project wafer production, to develop a proof of concept in a cost-efficient manner. 'The fabrication process is something standard,' clarifies Sciberras, 'we're using a commercially available platform, rather than developing the process ourselves because we don't have that capability here at the university. What we do here is the design.'

In practice, working at this size doesn't offer any other disadvantage in manufacturing or application. If successfully applied, the gripper could make the process of diagnosis much easier and less costly. Currently, diagnosing pathologies in blood cells might require greater specialisation and pricier machinery, such as atomic force microscopes, a powerful tool that allows scientists to see and manipulate individual atoms on the surface of materials (incidentally, if that sounds expensive, that's because it is! Prices can vary from tens of thousands to several hundred thousand euros). Hopefully, MEMSGRIP's clinical applications will make diagnosing diabetes and similar diseases more accessible to health professionals without any advanced training or steep costs. That means that patients could also count on quicker healthcare treatments.

Despite being smaller than a strand of human hair, the MEMS gripper could make a big difference! Ultimately, miniaturisation opens the door for new technological applications and innovations. In this day and age, sending a magical yellow school bus full of children inside a human body seems almost outdated. There are much more thrilling (and real) advancements in the world of micro and nanotechnology! **T**

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