Institute of Materials Research and Engineering
A*STAR

MEDIA RELEASE
Embargoed till 28 June 2011, 10.00am Singapore time

Creating new advanced R&D tools that can build molecule-sized computer chips

*The Institute of Materials Research and Engineering (IMRE), a research institute of Singapore's Agency for Science, Technology and Research (A*STAR), hosts the first AtMol workshop for the world's experts in the advanced tools needed to build a molecule-sized chip. IMRE is the perfect venue as it houses one of the few R&D tools in the world that is powerful enough to study single molecule logic gates and surface atom circuit logic gates, which are essential in building the chip.*

1. **Singapore, 28 June 2011** – Tools that are able to build computer chips 1000 times smaller than a grain of sand. That's what experts from around the world will be talking about when they gather at A*STAR's IMRE for a workshop on atomic scale interconnection machines. The tools are vital to the European Union's €10 million *Atomic Scale and Single Molecule Logic Gate Technologies*, or AtMol project in which IMRE is the only non-EU partner. The project lays the foundation for creating and testing a molecule-sized processor chip.

2. These tools physically move atoms into place one at a time to construct atomic scale circuits at cryogenic temperatures and are also able to interconnect the tiny circuits to the external environment. The machines are essentially miniature high precision scanning tunnelling microscopes that can image a surface with picometer precision and manipulate one atom or molecule at a time. They are coupled to a high-resolution electron microscope that allows a researcher to position interconnects to make an atomic scale circuit. This method is a leading alternative in the race to achieve continued miniaturisation of nanoelectronic devices. It is estimated that conventional methods for shrinking devices will reach their miniaturisation limit in 10-15 years and cannot be reduced further. Speakers from Europe, USA, Japan, Canada, Australia and Singapore will discuss advancements in such ultra-high vacuum (UHV) tools and plans for the next generation tools.

3. "Because we are working at the scale of the atom, our tools have to be ultra high-precision and of extremely high-calibre, just like IMRE's UHV interconnection machine, which is one of the three in AtMol that can study the performance of single molecule and surface atom circuit logic gates", said the AtMol project leader, Prof Christian Joachim of the French Centre National de la Recherche Scientifique (CNRS) and an A*STAR Visiting Investigator at IMRE. Prof Joachim's team in IMRE is one of the pioneers in atom technology, having built the world's first controllable molecular gear and constructed the smallest digital logic gate with a single molecule. "This workshop brings together the world's foremost experts to discuss the latest in atomic interconnection machine technology and how this can quicken the pace towards a working molecular chip."

4. "The tools and the level of expertise that IMRE is contributing to this project show that the research in Singapore is truly at the cutting edge of global science", said Prof Andy Hor, Executive Director of IMRE. "IMRE is extremely glad to host the event and be a part of a truly momentous scientific effort."

5. The AtMol project aims to create a prototype molecular processor or a 'concept chip' in about four years time. The project will establish a comprehensive process for making the molecular chip using the three unique ultra high vacuum (UHV) atomic scale interconnection machines to build the chip atom-by-atom. The AtMol project was launched at the start of 2011 with 10 organisations from across Europe and IMRE in Singapore.

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Encl. Appendix A: ***Infographic*** **-** Machines that build and connect atomic scale circuits

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About the Institute of Materials Research and Engineering (IMRE)
The Institute of Materials Research and Engineering (IMRE) is a research institute of the Agency for Science, Technology and Research (A*STAR). The Institute has capabilities in materials analysis & characterisation, design & growth, patterning & fabrication, and synthesis & integration. We house a range of state-of-the-art equipment for materials research including development, processing and characterisation. IMRE conducts a wide range of research, which includes novel materials for organic solar cells, photovoltaics, printed electronics, catalysis, bio-mimetics, microfluidics, quantum dots, heterostructures, sustainable materials, atom technology, etc. We collaborate actively with other research institutes, universities, public bodies, and a wide spectrum of industrial companies, both globally and locally.

For more information about IMRE, please visit www.imre.a-star.edu.sg

About the Agency for Science, Technology and Research (A*STAR)
The Agency for Science, Technology and Research (A*STAR) is the lead agency for fostering world-class scientific research and talent for a vibrant knowledge-based and innovation-driven Singapore. A*STAR oversees 14 biomedical sciences and physical sciences and engineering research institutes, and six consortia & centres, located in Biopolis and Fusionopolis as well as their immediate vicinity.

A*STAR supports Singapore's key economic clusters by providing intellectual, human and industrial capital to its partners in industry. It also supports extramural research in the universities, hospitals, research centres, and with other local and international partners.

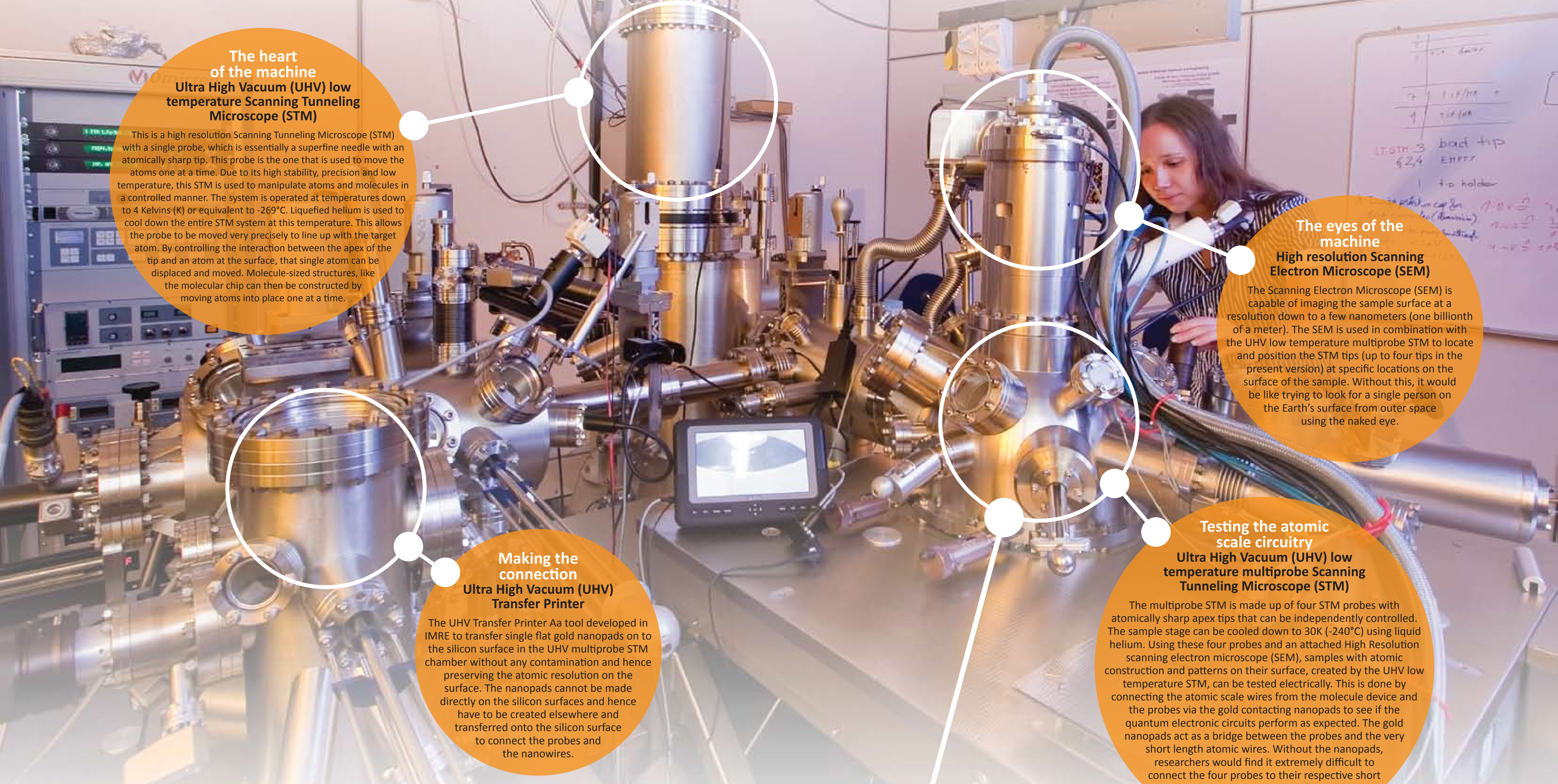
For more information about A*STAR, please visit www.a-star.edu.sg.

About the AtMol project
AtMol will establish comprehensive process flow for fabricating a molecular chip, i.e. a molecular processing unit comprising a single molecule connected to external mesoscopic electrodes with atomic scale precision and preserving the integrity of the gates down to the atomic level after the encapsulation. Logic functions will be incorporated in a single molecule gate, or performed by a single surface atomic scale circuit, via either a quantum Hamiltonian or a semi-classical design approach. AtMol will explore and demonstrate how the combination of classical and quantum information inside the same atomic scale circuit increases the computing power of the final logic circuit. Atomic scale logic gates will be constructed using atom-by-atom manipulation, on-surface chemistry, and unique UHV transfer printing technology.

For more information about AtMol, please visit www.atmol.eu

Machines that build and connect atomic scale circuits

The atomic scale interconnection machines needed to assemble a molecule-sized processor chip are essentially a combination of a number of high-powered microscopy systems. One system is a high precision scanning tunneling microscope (STM) that can image a surface with a picometer precision (one million times more powerful than a conventional light microscope) and manipulate one atom or molecule at a time to construct an atomic scale circuit. This STM is UHV and low temperature connected to a UHV high-resolution electron microscope that allows a researcher to position the 4 tips of 4 LT-UHV STM that interconnects this atomic scale circuitry. Atom scale technology is a leading alternative in the race to achieve continued miniaturisation of nanoelectronic devices. It is estimated that these devices will reach their miniaturisation limit in 10-15 years and cannot be reduced further.



The heart of the machine
Ultra High Vacuum (UHV) low temperature Scanning Tunneling Microscope (STM)

This is a high resolution Scanning Tunneling Microscope (STM) with a single probe, which is essentially a superfine needle with an atomically sharp tip. This probe is the one that is used to move the atoms one at a time. Due to its high stability, precision and low temperature, this STM is used to manipulate atoms and molecules in a controlled manner. The system is operated at temperatures down to 4 Kelvins (K) or equivalent to -269°C. Liquefied helium is used to cool down the entire STM system at this temperature. This allows the probe to be moved very precisely to line up with the target atom. By controlling the interaction between the apex of the tip and an atom at the surface, that single atom can be displaced and moved. Molecule-sized structures, like the molecular chip can then be constructed by moving atoms into place one at a time.

The eyes of the machine
High resolution Scanning Electron Microscope (SEM)

The Scanning Electron Microscope (SEM) is capable of imaging the sample surface at a resolution down to a few nanometers (one billionth of a meter). The SEM is used in combination with the UHV low temperature multiprobe STM to locate and position the STM tips (up to four tips in the present version) at specific locations on the surface of the sample. Without this, it would be like trying to look for a single person on the Earth's surface from outer space using the naked eye.

Making the connection
Ultra High Vacuum (UHV) Transfer Printer

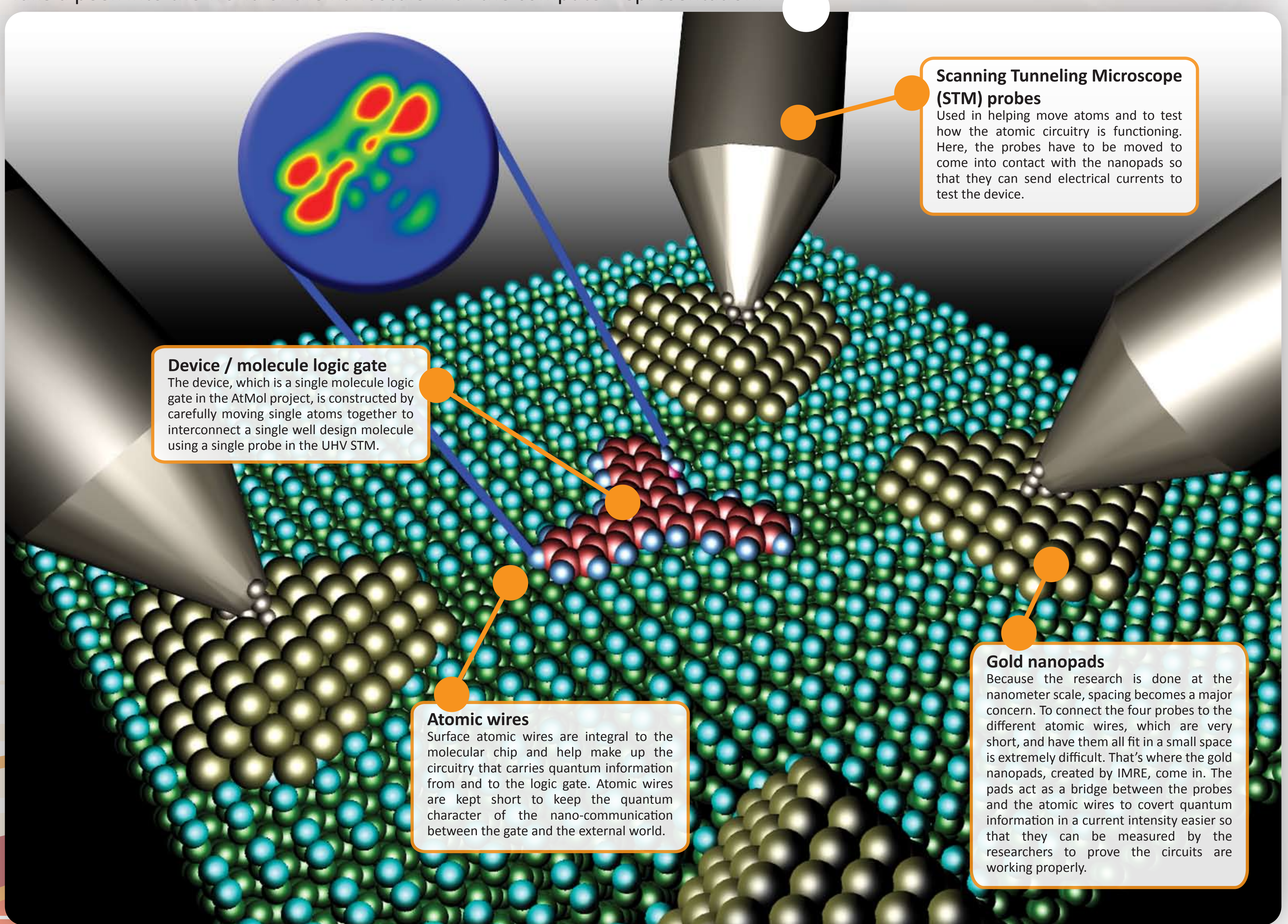
The UHV Transfer Printer Aa tool developed in IMRE to transfer single flat gold nanopads on to the silicon surface in the UHV multiprobe STM chamber without any contamination and hence preserving the atomic resolution on the surface. The nanopads cannot be made directly on the silicon surfaces and hence have to be created elsewhere and transferred onto the silicon surface to connect the probes and the nanowires.

Testing the atomic scale circuitry
Ultra High Vacuum (UHV) low temperature multiprobe Scanning Tunneling Microscope (STM)

The multiprobe STM is made up of four STM probes with atomically sharp apex tips that can be independently controlled. The sample stage can be cooled down to 30K (-240°C) using liquid helium. Using these four probes and an attached High Resolution scanning electron microscope (SEM), samples with atomic construction and patterns on their surface, created by the UHV low temperature STM, can be tested electrically. This is done by connecting the atomic scale wires from the molecule device and the probes via the gold contacting nanopads to see if the quantum electronic circuits perform as expected. The gold nanopads act as a bridge between the probes and the very short length atomic wires. Without the nanopads, researchers would find it extremely difficult to connect the four probes to their respective short atomic wires in that very confined space.

A peek inside...

Have trouble imagining how putting a molecular chip together would look like? Take a peek into the world of the nanoscale with the computer representation.



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AtMol