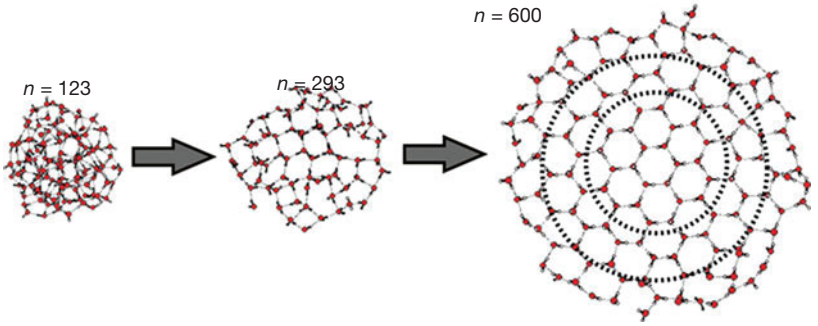

With increasing size, very cold clusters of water molecules arrange themselves as a real ice crystal. (a) When there are 123 water molecules, clusters are still completely unstructured—like a rigid liquid; (b) when there are just under 300 molecules, the hexagonal structure of the ice crystal is already discernible in the cluster's core; (c) when there are 600 molecules, the interior of the ice crystal is already perfectly formed, only the outer layer is still amorphous.
Credit: Udo Buck

too small to crystallize, they instead form a disordered, amorphous spatial lattice.

As such clusters increase in size, the water molecules at their core can change at some stage from a disordered into an ordered crystalline structure. This was first observed with 275 water molecules, where the first crystalline structure is observed in the interior of the cluster and comprises a ring of six hydrogen-bonded water molecules in a tetrahedral configuration.

To begin with, this structure is still slightly deformed. However, as the cluster increases in size, this interior grows to become a nicely ordered ice crystal, while the outer layers remain amorphous. "When there are 475 molecules, the very core is already perfect," says Buck.

As reported in the September 21 issue of *Science* (DOI: 10.1126/science.1225468; p. 1529), the researchers doped the cluster with a sodium atom and used IR excitation–modulated photoionization spectroscopy to pinpoint the onset of crystallization. Zeuch says that the sodium atom enables the cluster to be gently ionized, sorted with an electric field, and measured specifically.

The sodium atom on the surface of the water cluster also has a second function. "It acts as a type of photographic paper," says Zeuch. "We initially irradiate the clusters containing the sodium atom with the infrared light. Then we 'develop' it with a laser pulse of ultraviolet light." The sodium atom provides an infrared spectrum of the tiny water cluster. This decisive trick was the breakthrough.

The researchers now want to experimentally investigate the crystallization of other substances and their surface properties as well—accurate to one molecule, where possible.

Nano Focus

Germanium lasers may close Moore's Gap

An international team of researchers has investigated the mechanisms necessary for enabling germanium to emit laser light. As a laser material, germanium together with silicon could form the basis for innovative computer chips in which information would be transferred partially in the form of light. This technology would revolutionize data streaming within chips and give a boost to the performance of electronics. Hans Sigg of the Paul Scherrer Institute (PSI) and Jérôme Faist of ETH Zurich in Switzerland, Giovanni Isella of Politecnico di Milano in Italy, and their colleagues have demonstrated that germanium must be put under strain by an external force in order to turn it into a laser material.

While much progress has been made to increase the number of transistors in computer chips, the overall performance of processors has not been able to follow Moore's law for the past decade, and specialists are now talking about "Moore's Gap." The reason for this is that modern chips have more cores—individual processors—that can only relatively slowly communicate with each other using current technology.

"Actually, we do know a way in which this gap can be closed. The key concept is 'optical data transfer between the different cores on the chip," says Sigg. "This means partially transferring information inside a chip with the aid of laser pulses, which would significantly speed up the information exchange." In order to do this, tiny lasers are needed that can be built into chips to send out light pulses.

As reported in the August 3 issue of *Physical Review Letters* (DOI: 10.1103/PhysRevLett.109.05740; 057402), the researchers investigated those properties of germanium that are important for the generation of laser light, and compared them with those of currently available laser materials. Specifically, they quantified optical gain as a function of carrier density, strain, and doping, and highlighted the role of valence intraband absorption in limiting optical amplification for lasing.

"Our results are, on the one hand, encouraging, because germanium behaves similarly to traditional laser materials, and therefore the possibility of it emitting light cannot be excluded," says Sigg, "but with the limitation that the balance between amplification and loss is still so unfavorable in the germanium layers investigated so far that the material does not yet fulfill the condition for emitting laser light." But it has been demonstrated that this condition can be more closely approached the more the germanium is put under strain using an external force.

Correction
In the October 2012 issue of *MRS Bulletin*, Reference 27 should be cited for Figure 2 on page 933: M.J. Maloney, in *Turbine Forum* (Forum of Technology, Germany, Nice-Port St. Laurent, France, 2006).

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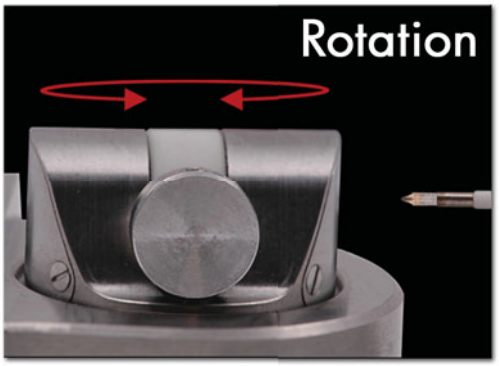

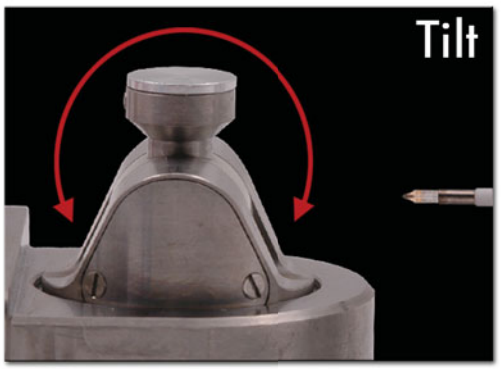

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