Tetrahertz moves to the near field

CHARACTERIZATION

Passing through materials that are opaque to visible light, terrahertz waves offer advantages in imaging applications. However, near-field imaging, beneficial for achieving high spatial resolution and better sensitivity, can be problematic in the terrahertz region with the detector located remotely from the probe.

An integrated device combining aperture, probe and detector on a single semiconductor chip has been developed at the Advanced Device Laboratory, Saitama, Japan, removing the need for optical and mechanical alignments [Kawano et.al., Nature, doi: 10.1038/nphoton.2008.157].

Near-field imaging is well established in the visible and microwave regions but sensitivity is commonly degraded by the separation of detector and probe, allowing the influence of far-field waves. Near-field terrahertz systems use a small aperture, with a consequent weak field and small wave area, and a collecting tip that is prone to picking up the stronger far-field background signal.

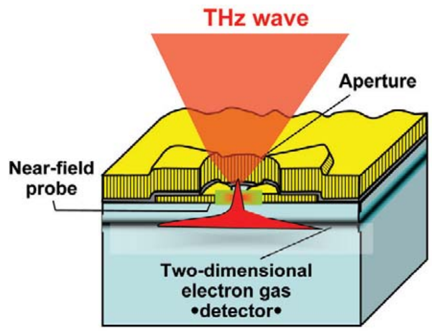


Figure showing an on-chip near-field terahertz probe and detector.

The new device efficiently detects only the evanescent wave with a planar probe that is integrated with the detector, eliminating the need for separate waveguide and lens. The 8 μm aperture and planar probe, separated by a layer of silicon dioxide insulation, are deposited onto a GaAs/AlGaAs chip with a rectangular detector of 2D electron gas (2DEG) 60nm below the chip surface. The evanescent wave induces resistance heating of the 2DEG and, because it is a two-dimensional layer, it is unaffected by the far-field wave. The planar probe effectively changes the spatial distribution of the evanescent field so that it is better coupled to the detector in the same plane.

"A resolution of 9 μm has been obtained using the system and further improvements are expected with the use of a detector based on carbon nanotubes, expected to exhibit higher sensitivity and resolution as well as operating temperature improvements," explains Yukio Kawano. The resulting sub-micron device could be used at room temperature and is likely to open up new applications in chemistry, physics and engineering.

Jon Hobden

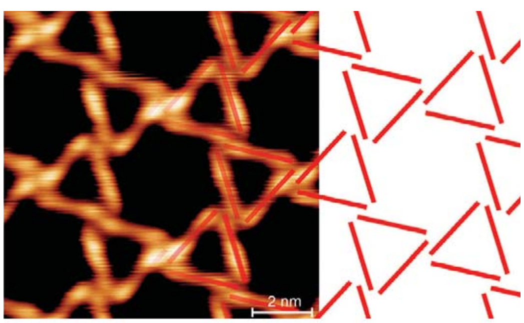
Simple building blocks show a complex side

POLYMERS AND SOFT MATERIALS

The self-assembly of small molecular 'building blocks' into large and ordered structures, inspired by biological systems, is a highly attractive prospect because it does not involve complicated synthetic pathways or external manipulation. Despite intense research, however, the relation between the chemical nature of the building blocks and the structure that is ultimately formed remains challenging.

Now a team from Switzerland, Germany, and Canada have taken the idea of a structurally simple building block to a new level by developing a series of achiral molecules, consisting of a linear chain of three to five phenyl rings endcapped by carbonitril groups NC-Ph(3-5)-CN. In fact, the structural simplicity of these molecules is such that the team chose to refer to them as 'molecular bricks' [Schlickum *et al., J. Am. Chem. Soc.*, doi: 10.1021/ja8028119].

After vapor-deposition of these molecules on a silver substrate and imaging by scanning tunneling microscopy (STM), the researchers found that long-range periodic lattices emerged for all three building blocks. Despite the structural similarity of the constituents, different structures were formed,



Using a series of structurally simple and low-symmetric molecules, researchers have demonstrated the self-assembly of chiral long-range crystalline networks, including the elusive kagomé lattice.

increasing in complexity with the increasing length of the molecules. In particular, the NC-Ph_3-CN molecules assembled into a chevron-layer structure, while the NC-Ph_4-CN groups assembled into an open-rhombic network.

The most surprising finding, however, was observed for the NC-Ph_5-CN molecules, which assembled into a complex structure known as a kagomé lattice. This periodic framework, characterized by a series of hexagonal pores surrounded by triangles, is one of only eleven general ways in which a plane can be filled by regular polyhedrons. Despite occurring naturally in some minerals, and having been studied extensively for their unusual magnetic properties, kagomé lattices have been observed only a few times in self-assembled networks so far. In contrast to these previous reports, however, the ordering in the present study is obtained based on the simple, low-symmetric linear bricks.

"Our results demonstrate that, with the help of self-assembly processes, it is possible to fabricate complex surface patterns even with simple linear molecular bricks, Uta Schlickum, tells *Materials Today*. He goes on to say "Such patterned surfaces are of high relevance for example applications such as surface refinement or data storage, and are the result of the interplay between molecule-molecule interactions, the substrate epitaxial fit and the conformational flexibility of the molecules. "Uta Schlickum continues, "Our results help to understand the mechanisms involved in self-assembly processes. A detailed understanding of these processes would lead to a strongly enhanced ability to fabricate any surface pattern needed in an easy, inexpensive way and with atomic precision."

Peter Dedecker