Measuring the Spatial Resolution of the Laser Terahertz Emission Microscope System

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The laser terahertz emission microscope (LTEM) system can be used to visualize the local electric field distribution of any material or device that emits terahertz radiation after excitation by a femtosecond laser. Spatial resolutions of better than 2 μm have already been achieved. To improve the spatial resolution, a beam expander and a high numerical aperture objective lens were introduced into the setup so that the spot-size of the laser beam could be reduced. In order to measure the new spatial resolution we carried out THz-radiation imaging of line and space patterns of Ti/Au/Ti on InP, with lines of width 5 μm and spaces varying from 2 μm to 0.5 μm, irradiated by a femtosecond laser pulse with wavelength 780 nm. Resolutions of less than 1 μm can be obtained. The improved resolution will provide better images that can be used to study materials such as semiconductors, high-T_c superconductors (HTSC), colossal magneto-resistance manganites, and multiferroic materials, nondestructively.

Terahertz Emission Imaging at Submicron Resolutions

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Terahertz Technology

Until quite recently, very little was known about what is now known as the Terahertz region of the electromagnetic spectrum. Advances in laser technology have allowed researchers to study these waves, called T-Rays, and use them for many modern day applications which include non-intrusive imaging for medical, security and industrial applications.

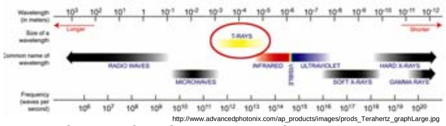
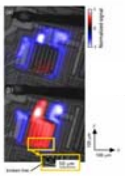


Fig. 1 - The Electromagnetic Spectrum

Laser Terahertz Emission Microscope (LTEM)

The LTEM is a recently developed microscope for imaging the terahertz emission from various kinds of materials when they are excited by a femtosecond laser.



Applications in Basic Science

Visualizing the physical information in materials since terahertz emission properties reflect the carrier dynamics and intrinsic nature of the materials.

Industrial Application

Nondestructively inspecting electrical faults in integrated circuits such at those in the picture above.

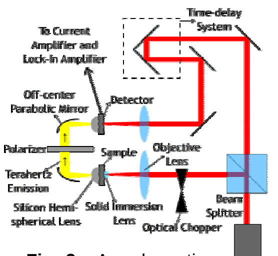


Fig. 2 - A schematic diagram of the optical setup used to obtain THz images.

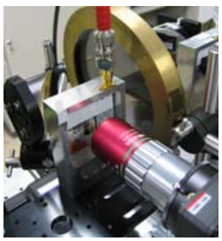


Fig. 3 – A close-up of part of the system. The objective lens, sample, solid immersion lens, parabolic mirrors and polarizer can be seen.

Improving the Spatial Resolution

The system could already produce images with a resolution of up to 2 microns. Our goal was to reduce this limit to less than 1 micron.

Unlike most imaging systems, the resolution of images obtained from the LTEM is not limited by the wavelength of the light used, but by the beam size. *A narrower beam results in a better image.*

To reduce the beam's spot size, we introduced a *Solid Immersion Lens* between the objective lens and sample.

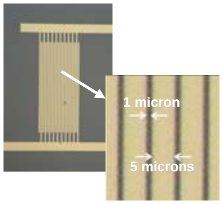
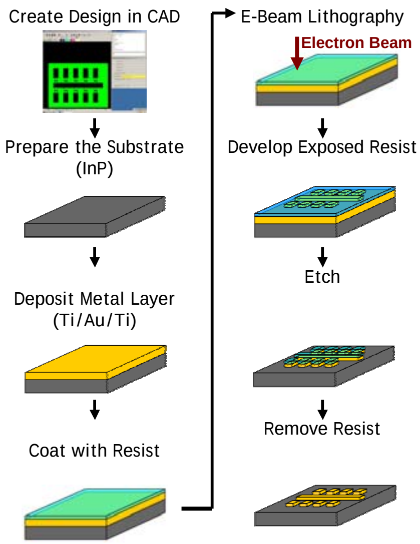


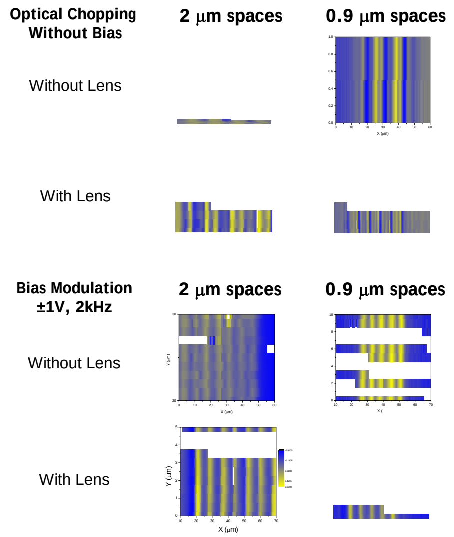
Fig. 4 – Line and space patterns such as this one were used to evaluate the resolution of the improved system.

Making the Sample



Results

- *Clearer images* were obtained when the Solid Immersion Lens was present.
- Spaces with a width of 0.9 microns could be clearly distinguished in the images generated indicating that the resolution is certainly less than 1 micron.



Next Step

It presently takes about 60 minutes to produce the images above. Obtaining images that at near real-time speeds would greatly increase the usefulness of the system.

Acknowledgments

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Tonouchi Lab

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