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-Tc superconductors (HTSC), colossal magneto-resistance manganites, and multiferroic materials, nondestructively.
Until quite recently, very little was known about \( \text{\textit{T}} \)-rays, also known as Terahertz waves, that are located on 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.

To improve the spatial resolution, \( \text{\textit{T}} \)-ray scientists introduced a solid immersion lens. Unlike most imaging systems, the resolution of 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.

**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. Without the solid immersion lens present, the resolution was clearly distinguished in the images generated indicating that the resolution is certainly less than 1 micron.

**Applications in Basic Science**

Visualizing the physical information in materials since \( T \)-ray emission properties reflect the carrier dynamics and intrinsic nature of the materials.

**Industrial Application**

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

**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.

**Optical Chopping**

<table>
<thead>
<tr>
<th>Bias Modulation</th>
<th>Without Bias</th>
<th>With Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Lens</td>
<td>2 ( \mu \text{m} ) spaces</td>
<td>0.9 ( \mu \text{m} ) spaces</td>
</tr>
<tr>
<td>With Lens</td>
<td>2 ( \mu \text{m} ) spaces</td>
<td>0.9 ( \mu \text{m} ) spaces</td>
</tr>
</tbody>
</table>

**Making the Sample**

1. Create Design in CAD
2. E-Beam Lithography
3. Prepare the Substrate (InP)
4. Develop Exposed Resist
5. Deposit Metal Layer (Ti/Au/Ti)
6. Etch
7. Remove Resist
8. Coat with Resist

**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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