Holographic X-ray camera

Dipl.-Phys. Dirk Berben and Prof. Dr. Karsten Buse University of Bonn, Institute of Physics, Wegelerstr. 8, 53115 Bonn

Summary

A new x-ray imaging sensor is realized that is based on erasure of elementary holograms: By interference of two visible light beams a reflection hologram is recorded in photorefractive iron-doped lithium niobate crystals. Illumination of such a crystal with an x-ray image erases the hologram in the portions of the crystal where x-ray light is present. Afterwards a plane wave is shined onto the crystal. The light is diffracted only from such crystal regions where the hologram is still present. Thus the diffracted pattern of visible light is a replica of the original x-ray image. The hologram and the crystal act as an "x-ray-to-visible image converter". The visible light can be detected with, e.g., a CCD camera. By usage of so-called "thermally fixed" holograms the holographic recording must be done only once and then the hologram can be used many times. No chemical development is required.

Many different methods to detect x-rays were developed. Films, scintillator materials, charge-coupled devices and several others. Anyhow, our detection system is of considerable importance because of its combination of positive features: (1) The spatial resolution is very high. In first experiments we obtained 25 µm. We currently improve this to 5 urn. (2) The area of the detector can be large. Crystals with 5 inch diameter are available. Considering the 5 urn resolution, this corresponds to an effective number of pixels of about 100 million. (3) The detector is suitable for hard x-rays without any fading or long-term damage. (4) The detector has a logarithmic response which can be advantageous for images with strong changes of the x-ray intensity. Application areas are, e.g., material testing, safety control, and science. To detect microcracks in engines of planes, to check large and thick pieces of luggage with hard x-rays, and to measure the precise position of Bragg spots for advanced protein crystallography are selected possible applications. For medical applications the sensitivity of the detector is so far not good enough, however, further improvements may overcome this problem.

A first publication about the sensor appeared in August 2002 in "Applied Physics Letters". The article caused a lot of attention and many requests came. To enable commercial use we obtained patent protection at a very early stage. The patent was published in January 2003. The detector was developed by Dirk Berben within his PhD thesis work in a project where Karsten Buse is the principal investigator. The work was sponsored by the Deutsche Forschungsgemeinschaft und, later, by the Deutsche Telekom AG. Dirk Berben will finish his thesis in June 2003. We are seriously exploring different possibilities to introduce the developed x-ray detection system into the market.