MULTIPLE RERECORDING AND FIXATION OF HOLOGRAMS IN LITHIUM NIOBATE CRYSTALS DOPED WITH IRON

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Experiments are described on multiple recording and fixation of holograms in crystals of lithium niobate doped with iron. The recording was with the aid of an He-Ne laser (0.63 μ). Fixation was effected by heating the crystal to 75°C. The diffraction efficiency of the hologram is 16%.

It is known that the development of light-sensitive materials in which information can be erased and rerecorded is of great interest for holographic memory systems [1]. Experiments on the recording of interference of two plane waves in lithium niobate crystals doped with iron, using an argon laser operating at 4880 Å, are described in the literature [1], but holograms were never fixed in such crystals.

We have experimented with recording and fixation of holograms in lithium niobate crystals doped with 0.03 wt.% Fe, using a helium-neon (6328 Å) and a helium-cadmium (4416 Å) laser. In addition to the simplest holograms (plane waves), we obtained holograms of complex objects and found a method of fixing the obtained images. The sensitivity of the samples at 6328 and 4416 Å was 50 and 0.8 J/cm^2 (at a diffraction efficiency 24%). The maximum efficiency obtained at 6328 Å was 50%.

Holograms of complicated objects, particularly transparencies in the form of binary matrices, such as used in holographic memory devices, were obtained in accordance with the scheme shown in Fig. 1 [3]. The object was a metal plate with 1400 holes of 0.2 mm diameter spaced 0.8 mm apart. The angle between the reference and the object beams was approximately 15°, and the diameter of the hologram on the crystal surface was 3 mm. The crystal measured 5 x 5 x 5 mm. Using an He-Ne laser, the radiation power density on the hologram was about 0.05 W/cm^2 and the energy density approximately 40 J/cm^2. According to the experimental conditions, the intensity ratio of the reference wave and the radiation from the object was 30. The diffraction efficiency in the reconstruction of such a hologram was 3.1%. Figure 2 shows a photograph of the object and of its reconstructed image.

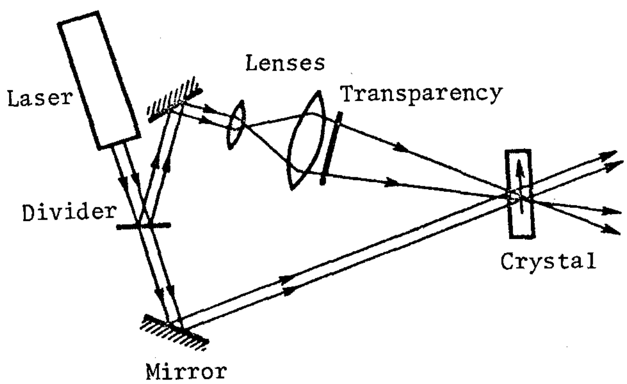

Fig. 1. Experimental setup for the production of transparency holograms.

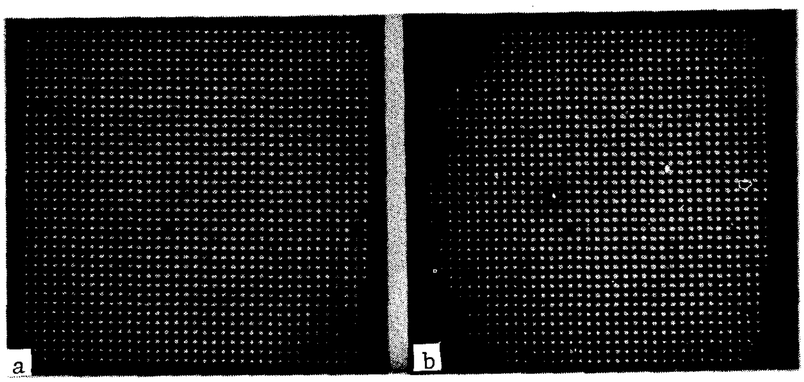

Fig. 2. Photographs of object (a) and of its virtual reconstructed image (b).

We investigated the possibilities of fixing holograms in iron-doped lithium niobate crystals and found a method whereby to store the information for an almost unlimited time. The sample with the recorded hologram was heated to 75°C. The heating continued for about 5 minutes and terminated before the image brightness began to decrease. The sample was then cooled to room temperature. Subsequent illumination of the hologram with the reference beam used in the photography, i.e., with an approximate power density 0.05 W/cm^2, led to a gradual enhancement of the brightness of the reconstructed image relative to the initial level. Such a fixation of the hologram of a binary matrix, with initial approximate efficiency 3%, enhanced the diffraction efficiency more than 5 times. The maximum efficiency (∼16%) has remained unchanged for several months by now. The hologram was read during that time with power density exceeding 0.05 W/cm^2 for a total of 30 hours. It should be noted that the mechanisms whereby the hologram is fixed and subsequently enhanced have not yet been satisfactorily explained.

We have also rerecorded holograms repeatedly in the same crystal sample. To erase the information, the sample was heated to 150°C. After fivefold rerecording, the diffraction efficiency of the hologram remained the same as in the first use.

Thus, our experiments lead to the conclusion that iron-doped lithium niobate crystals can be used even now as the recording medium in permanent memories, and offer the possibility of rerecording holograms. The development of methods of "fast" fixation of the recorded information will make it possible to realize on the basis of these crystals high-speed operative memories.

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[1] A. L. Mikaelyan, V. I. Bobrinev, S. M. Naumov, L. Z. Sokolova, Radiotekhnika i elektronika, 115 (1969).
[2] W. Phillips, J. J. Amodei, and D. L. Staebler, RCA Rev. 33, 941 (1972).
[3] A. L. Mikaelian et al., IEEE J. Quant. El. QE-4, 757 (1968).

ROLE OF ELECTRON-ELECTRON INTERACTION IN THE FORMATION OF A METASTABLE STATE OF METALLIC HYDROGEN

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We analyze the question of the stability of the results obtained for the metallic phase of hydrogen with respect to changes in the character of the approximations used to take the electron-electron interaction into account.

1. In [1] we considered the possible existence, in principle, and the structure of a metastable phase of metallic hydrogen. To this end we analyzed the energy and the static and dynamic stability for all Bravais lattices and for a number of diatomic lattices. The most essential of the results can be reduced to the following: 1) At zero pressure the metallic phase of hydrogen is a metastable and locally stable state. 2) All the symmetric (and cubic) structures are unstable. 3) The energy minimum is realized for a sharply anisotropic structure. 4) The metastable state is stable against decay into atoms (transition to the atomic phase).

2. The analysis in [1] was based on the use of perturbation theory in the electron-ion interaction (see [2] and the review [3]), with terms up to third order retained and with the electron-electron interaction taken into account in all terms of the series. This, naturally, raises the question of the stability of the foregoing results to improvement (change) of the character of the approximations.

We present in this article the results of an analysis of the role of a change in the character of the approximation when account is taken of the electron-electron interaction, and demonstrate that the results are qualitatively stable. The effect of higher terms of the expansion in the electron-ion interaction will be considered in a separate article.

3. Definite progress was made recently in the determination of the static polarization operator $\pi(\vec{q})$ at intermediate values of the electron density (see, e.g., [4, 5]). Its value