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HOMODYNE DETECTION OF DATA PAGES
IN LIPPMANN « HOLOGRAPHIC » MEMORIES

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1. Lippmann data storage

Lippmann interference architectures are alternatives to holographic memories for high capacity data storage [1-3]. In these systems, the image beam carrying the information data interferes with its reflection onto a mirror. The resulting interference pattern thus records a grating in the light sensitive material. Several images can be wavelength multiplexed at the same location. On the one side, and just as in holography, the number of images multiplexed in the same location is given by the wavelength Bragg selectivity of the thick gratings and is thus inversely proportional to the material thickness. On the other side, the page resolution is just diffraction limited and does not depend on this thickness. Each page can thus have a very large data content. Conversely to holography, no additional reference beam is required for recording. This absence of any reference beam simplifies the recording architecture at the expense on stringent requirements on the set-up adjustments [4]. However, the potential numerous advantages of the Lippmann architectures seem to justify these constraints. One of these advantages is the possibility to easily implement an homodyne detection that greatly enhances the detected signals. We presently use the arrangement depicted in Fig. 1.

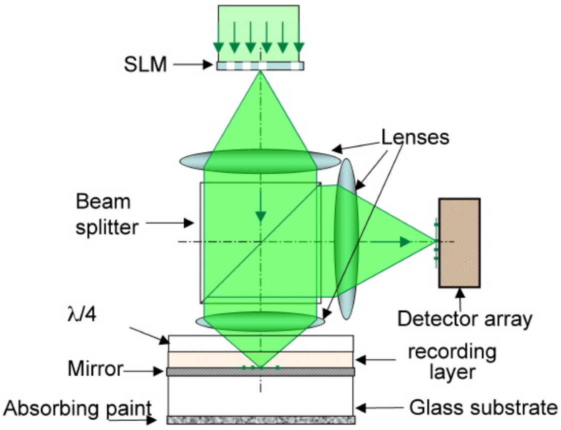

Fig. 1: Lippmann arrangement with homodyne detection. The system is shown during the recording phase (with only one SLM pixel ON for sake of clarity). During readout, all the pixels are ON.

During recording the data page displayed on the Spatial Light Modulator is imaged on the Lippmann mirror. Several pages are successively recorded, each of them at specific wavelength. The readout is performed with a plane wave at the exact wavelength used for recording. In conventional detection, the mirror is removed during readout, and only the diffracted intensity is detected. On the contrary, for the homodyne detection the mirror is let in place and the diffracted amplitude interferes with the plane wave corresponding to the readout wave reflected onto the mirror. This scheme, and some of its variants, was discussed and demonstrated for bit-oriented memories [5,6], but never for Lippmann page-oriented systems as presented below.

2. Experimental results

The optical set-up used for this demonstration is based on the scheme shown in Fig.1. It was described more precisely previously [4] and has now been adapted for homodyne detection. We feed the system with a filtered supercontinuum source. It can be continuously tuned from 460 to 600 nm with about a 3 nm full-width of half maximum of the amplitude. Unfortunately, if the low spectral density power of this source allows us to detect the recorded data, it is not sufficient for recording. This recording is thus performed with two lasers at 532 nm and 473 nm. The recording arrangement, see Fig.1, is a stack made of a partially reflecting dielectric mirror deposited on a glass substrate. Its intensity reflectivity is 8%. The recording layer is glued on this mirror and covered by a plastic quarter-wave plate. For this recording material, we use the full color Bayer photopolymer Bayfol® HX whose sensitive layer is 16 µm thick. The bottom of the glass substrate is painted with a light absorbing black material to prevent any scattering from light transmitted by the mirror. A zoom of a data page recorded at 532 nm and retrieved at 530 nm is shown in top of Fig.2 left. The pixel pitch is 0.88 µm for a numerical aperture of 0.6. It should be compared to the original data shown in the bottom of Fig.2 left in which the black color corresponds to no light (pixels OFF).

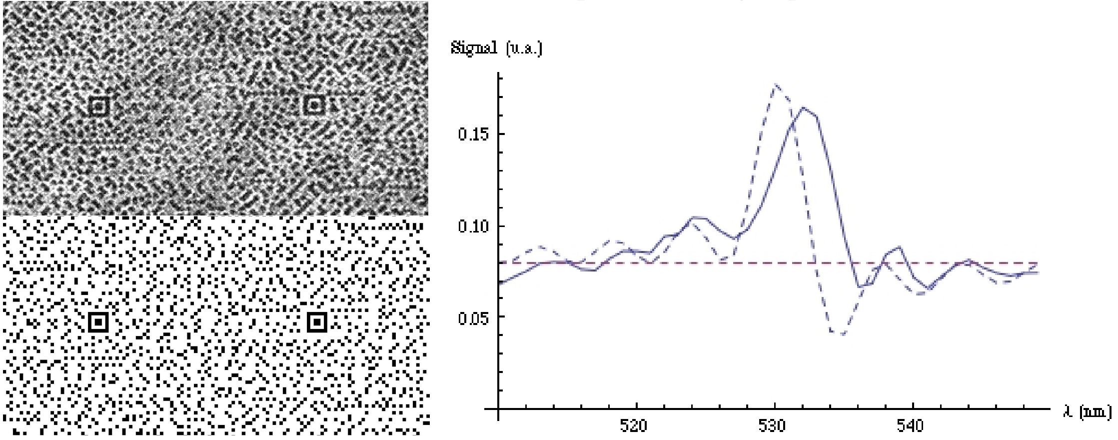

Fig. 2: Left: comparison between original page (bottom) and the retrieved data page (top). Right: detected signal for the whole page versus the wavelength, experimental curve in full line and simulation in dashed line. The dashed straight line corresponds to the mirror reflectivity.

The two curves in Fig.2 right, demonstrate a good agreement between the experimental wavelength selectivity in this homodyne scheme with the theoretical wavelength selectivity taking into account the material thickness and the spectral linewidth of the tuneable readout source. The small wavelength shift between the two curves is attributed to a very small material expansion. Before recording the image shown in Fig.2, we have deliberately strongly pre-exposed the material to limit the diffraction efficiency of the subsequently recorded image grating, thus demonstrating the effectiveness of the homodyne detection. The diffraction efficiency of the recording grating is indeed about 3.5% only.

3. Conclusion

Homodyne detection in Lippmann architectures is implemented “naturally”, that is just letting in place the “Lippmann” mirror and without any additional optical element. The agreements between our modelling and the first results are very promising. Other slightly different arrangements used to further improve the detected signal, arrangements similar to the ones already proposed for Lippmann bit oriented memories [6], will be discussed.

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