Arbeitsgebiet: K3: Mikroaktoren
Anwendungsbereich: A3: Mobilität

First Characterization of Comb Drive Based Micro Mirror Arrays

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The increasing demand for all kinds of Virtual, Mixed, and Augmented Reality systems drives the demand for 3D displays. Depending on the application various possible solutions are feasible. In our opinion, real time computer generated holograms (CGH) are the most promising approach to reach a high immersion without distracting physiological side effects like nausea, dizziness, motion sickness and eyestrain. Currently there are no spatial light modulators (SLM) available on the market that would fulfill the very challenging requirements for CGH. Therefor Fraunhofer IPMS and its partners are working on designing and manufacturing a suitable micro mirror array (MMA), a micro-electro-mechanical system (MEMS) based device, within the EU Horizon 2020 project REALHOLO, see [1]. This paper shows the first characterization results of our first MMA test chips and compares the general actuator response to the numerical simulations to further improve the manufacturing process.

Based on the previously published comb drive actuator design [2] to [4], the first devices are simplified passive MMA without a CMOS backplane and a reduced mirror count, because the purpose is the verification of the actuator manufacturing process (Fig. 3). The devices have a size of 6mm x 6mm with an active pixel area of 4mm x 4mm. The 670 by 1340 individual pixels have a pitch of 6x3µm. Due to the lack of an underlying CMOS an individual addressing of single pixels is not feasible. Therefor the individual pixels internally connected to groups that can be addressed by up to 48 individual voltages. This allows the generation of simple patterns which can be used for characterization and can be seen in Fig. 6.

For the characterization a white-light-interferometer (WLI) based setup was built at Fraunhofer IPMS (Fig. 1)The passive MMA can be measured by the WLI while it is addressed by a combination of three separate switch matrixes and a multi-channel SMU (Fig. 2). Since WLIs can only measure relative heights, the MMA is addressed in a pattern. While some pixels of the MMA are kept in the initial state at zero addressing voltage and serve as a reference, the others are addressed by various voltages and the resulting height difference is measured as the actual deflection for these voltages. After the measurement an image analysis routine is performed. This routine includes a pattern recognition algorithm to identify the individual pixels within the WLI surface height dataset. The dataset is then masked with a predefined mirror shape (Fig. 6) to automatically extract individual pixel parameters data. These are most importantly the height or deflection, the (in this application un-wanted) tilt in x and y directions, and the curvature of the mirror. This process is necessary to remove inconsistent data caused by the slits between the mirrors. By continuously adjusting the addressing voltage and measuring of the resulting deflection, the response curve of the pixels can be compiled (Fig. 5). These measurement results can later be compared to the numerical simulations of the actuator design (Fig. 4). A repetition of this kind of measurements at different locations on the MMA, leads to the spread of the mechanical parameters over the active pixel area that will be investigated in the future.

The paper shows the measurement data and the extraction of the mechanical parameter of the manufactured MMA devices and compares them with the previously published simulations, giving feedback to optimize manufacturing parameters and further improve the device properties.

Wortzahl: 561

References

[1] REALHOLO internet site: https://realholo.eu/

[2] P. Dürr, A. Neudert, M. Nitzsche, C. Hohle, H. Stolle, J. Pleikies, "MEMS piston mirror arrays for computer generated holography," Proc. SPIE 12013, MOEMS and Miniaturized Systems XXI, 1201306 (1 March 2022); doi: 10.1117/12.2608081

[3] Mario Nitzsche, Peter Duerr, Andreas Neudert, ' Improved comb drive design for MEMS piston mirror arrays', Proc. SPIP Photonics West 2023

[4] Peter Dürr, Andreas Neudert, Christoph Hohle, Hagen Stolle, Johannes Pleikies, Hagen Sahm: 'MEMS Spatial Light Modulators for Real Holographic 3D Displays', Proceedings of MicroSystemTechnik Kongress 2021

[5] A. Neudert, L. Felsberg, P. Dürr: ' MEMS Aktuator-Array mit Kammantrieb und verbesserter Linearität', MikroSystemTechnik Kongress 2019, ISBN 978-3-8007-5090-0 S. 197ff

Abbildungen:

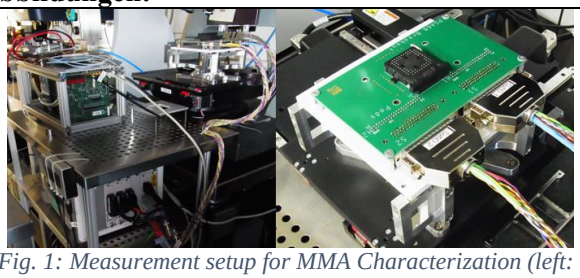

Fig. 1: Measurement setup for MMA Characterization (left: WLI- stage, switch matrix, PSU; right: Custom Breakout board for MMA addressing)

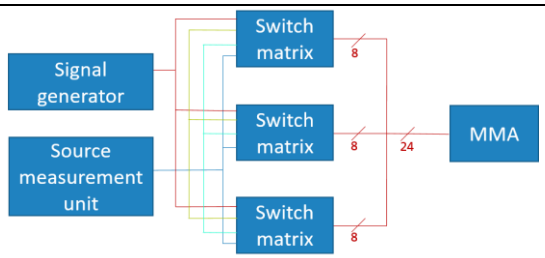

Fig. 2: setup for MMA WLI measurement

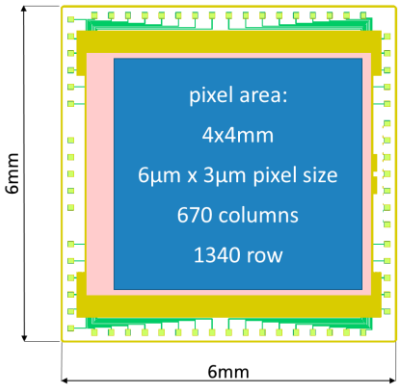

Fig. 3: simplified MMA design with 0.9MPixel

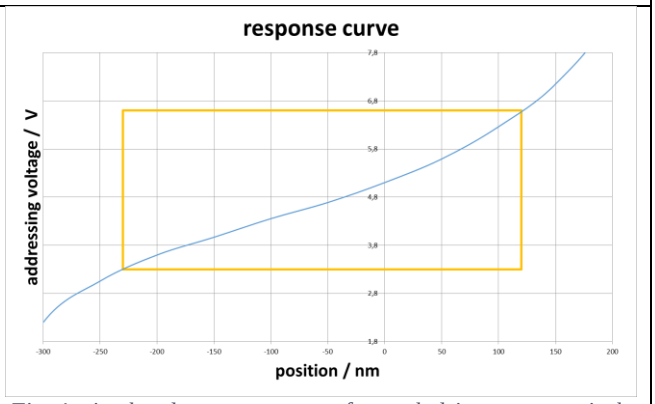

Fig. 4: simulated response curve of a comb drive actuator pixel and the desired operational windows (orange)

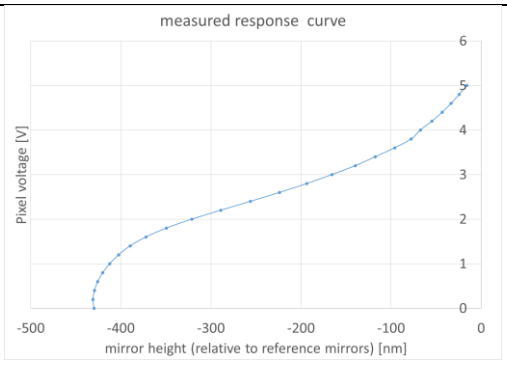

Fig. 5: measured response curve for individual pixel

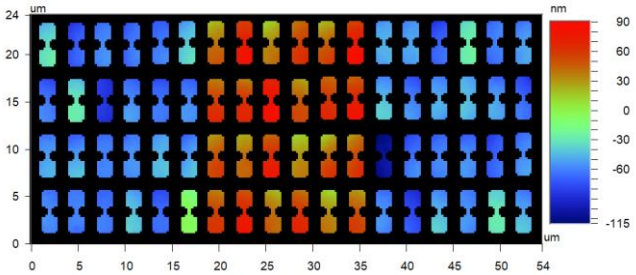

Fig. 6: WLI measurement data of an addressed passive REALHOLO MMA after post processing (pixel voltage 6V, six columns addressed, six columns reference)