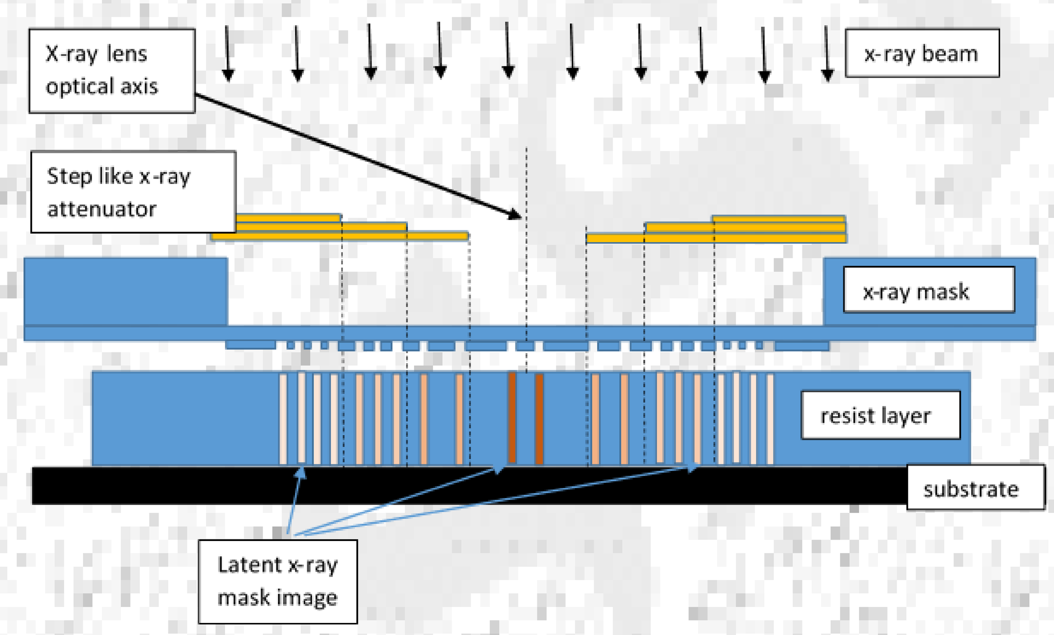
Self-aligned single exposure deep x-ray lithography

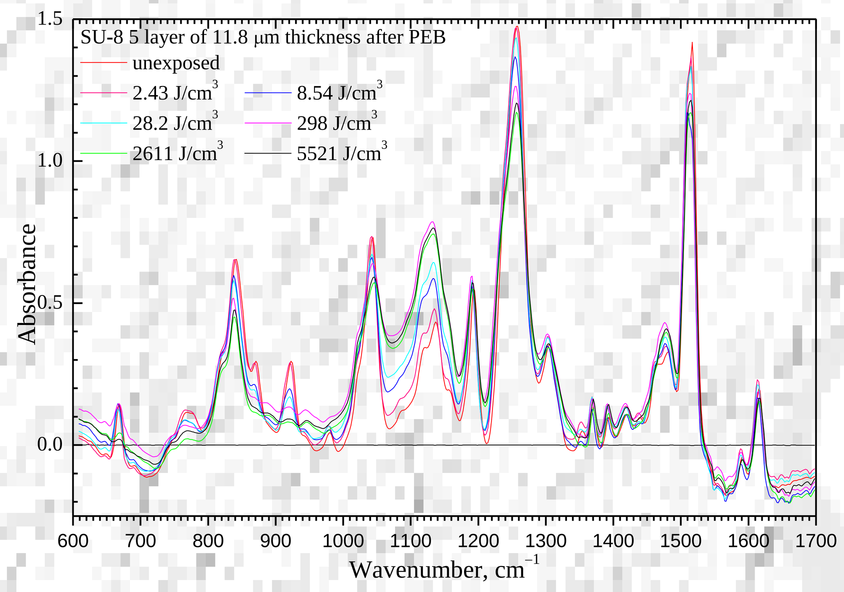
V.Nazmov[1,2], B.Goldenberg[1], E.Reznikova[1]
[1]Budker Institute of Nuclear Physics of SB RAS, 630090 Novosibirsk, Russia
[2]Institute of solid state chemistry and mechanochemistry of SB RAS, 630128 Novosibirsk, Russia
E-mail: V.P.Nazmov@inp.nsk.su

- Microdevices are usually made up of several interacting components that can be assembled on the basis of 3-dimensional LIGA structures, using various techniques to fulfill the required positioning accuracy - the so-called combined LIGA technology [1]. As a part of the LIGA technology, deep X-ray lithography enables the formation of 3-D microstructures of significant size in each of the three dimensions; however, it is often possible to improve positioning accuracy by using self-alignment technique when patterning with the use of X-ray mask, as shown in [2]. In our work, we consider single-exposure with self-alignment technique for the creation of microdevices of technological material, which can demonstrate new physical capabilities.

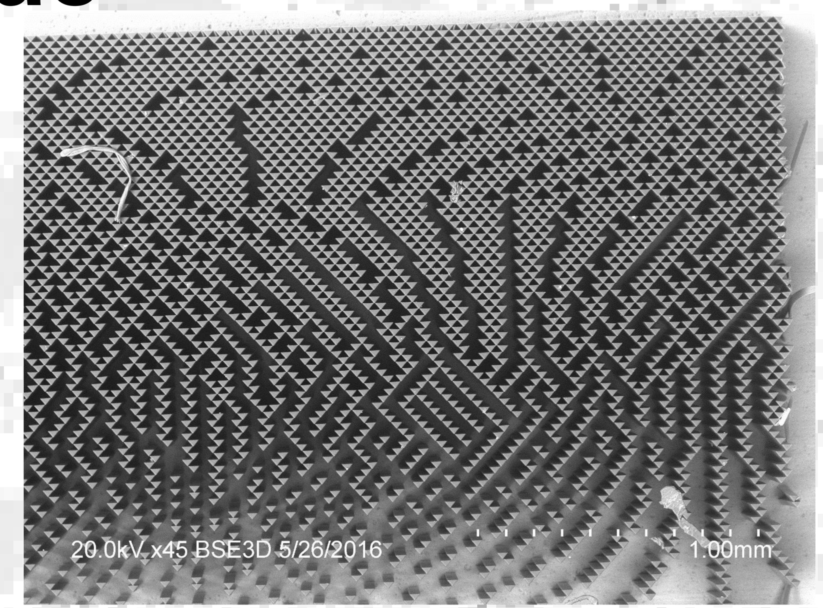
I. Self-aligned expose from planar side



Exposure scheme X-rays, including stepped attenuator

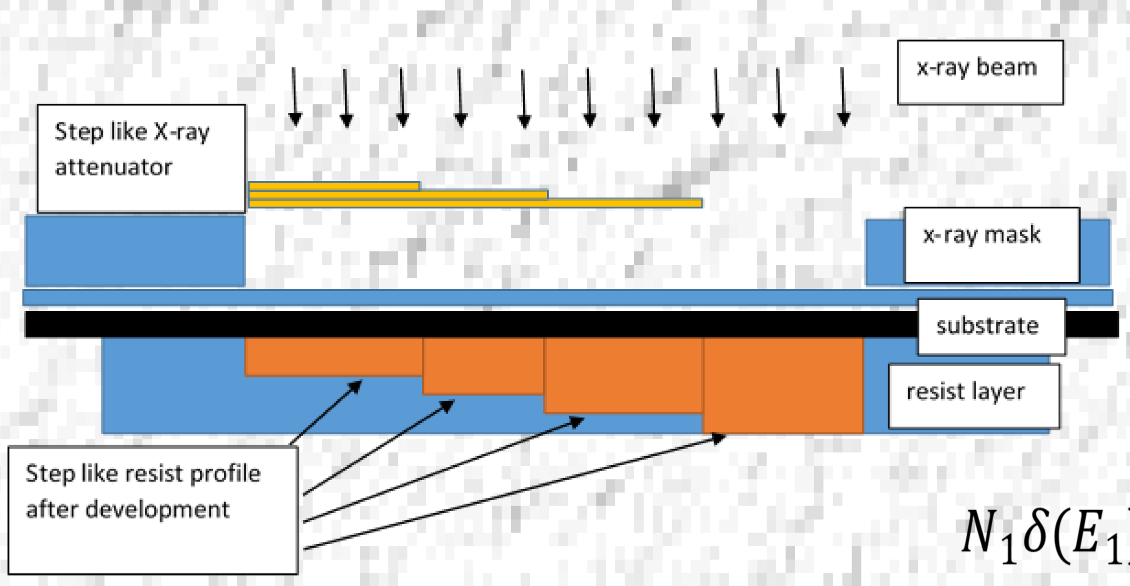


Measured IR-spectra of exposed SU-8 for different SR doses: increased peaks between 1091 nm and 1150 nm correspond more crosslinks into a polymer chain with the dose increase



Top view of refractive X-ray lens with mosaic arrangement made with the use of stepped attenuator with x-ray dose 90J/cm^3 at the optical axis and 40 J/cm^3 in the periphery

II. Self-aligned exposure from backside



Exposure scheme to X-rays, including stepped attenuator

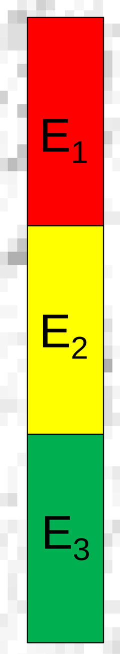
$$F = \frac{R}{2N\delta}$$

Three photon energies in one focal line

$$N_1\delta(E_1) = N_2\delta(E_2) = N_3\delta(E_3)$$

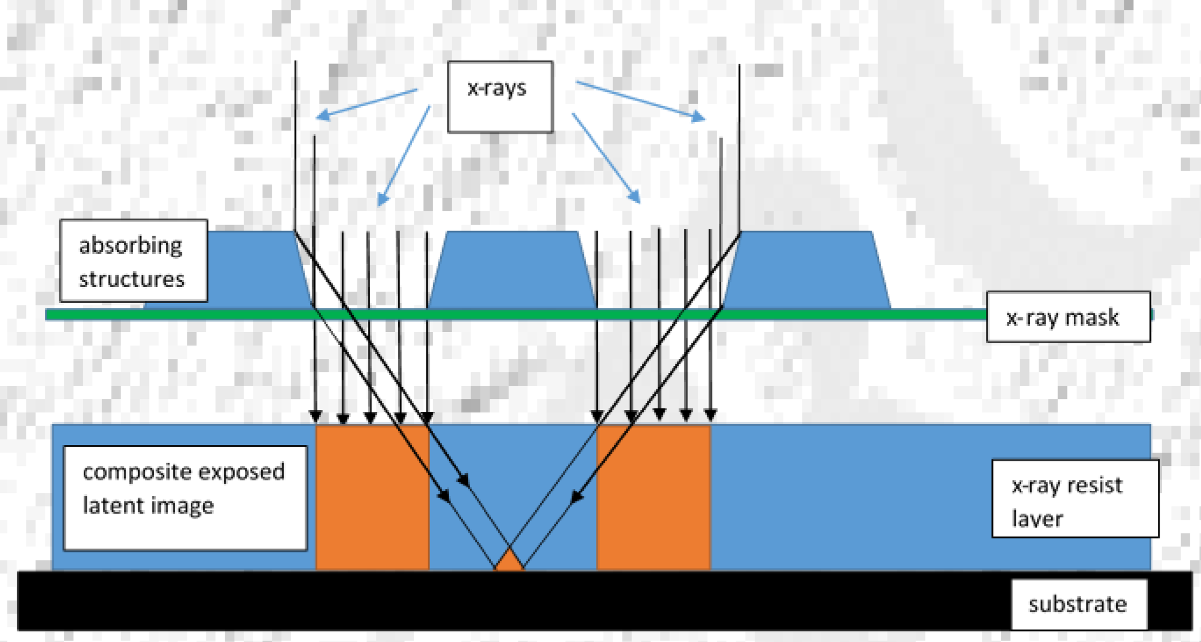
$N_{1,2,3}$ – refractive microstructures number; δ - refractive index decrement

Three X-ray lens, aligned into one lens, for three photon energies at the same focal distance

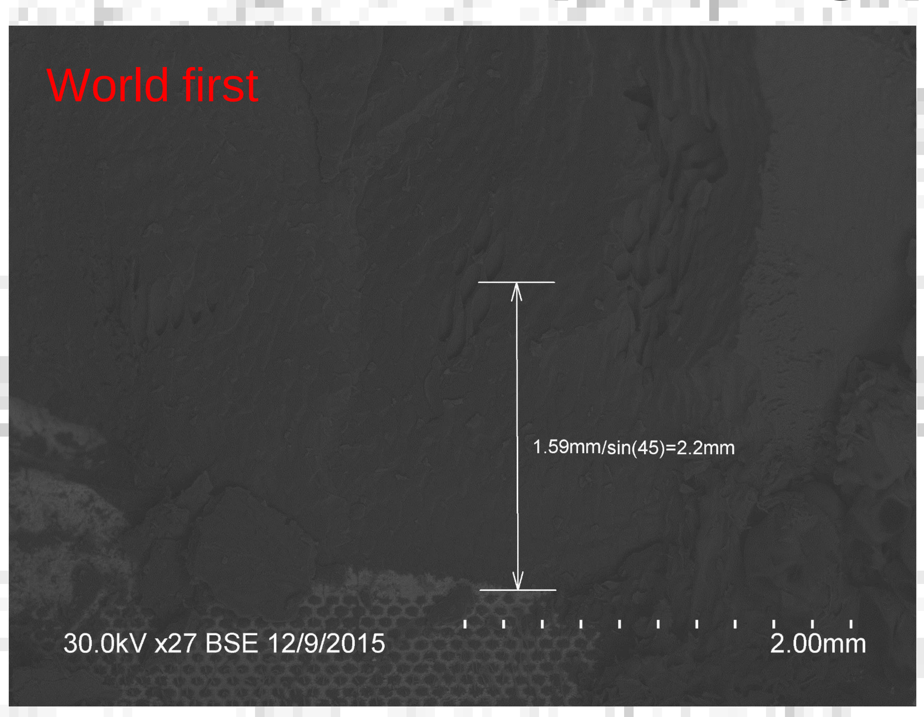


X-ray focus scheme containing its own sub-focus for each photon energy

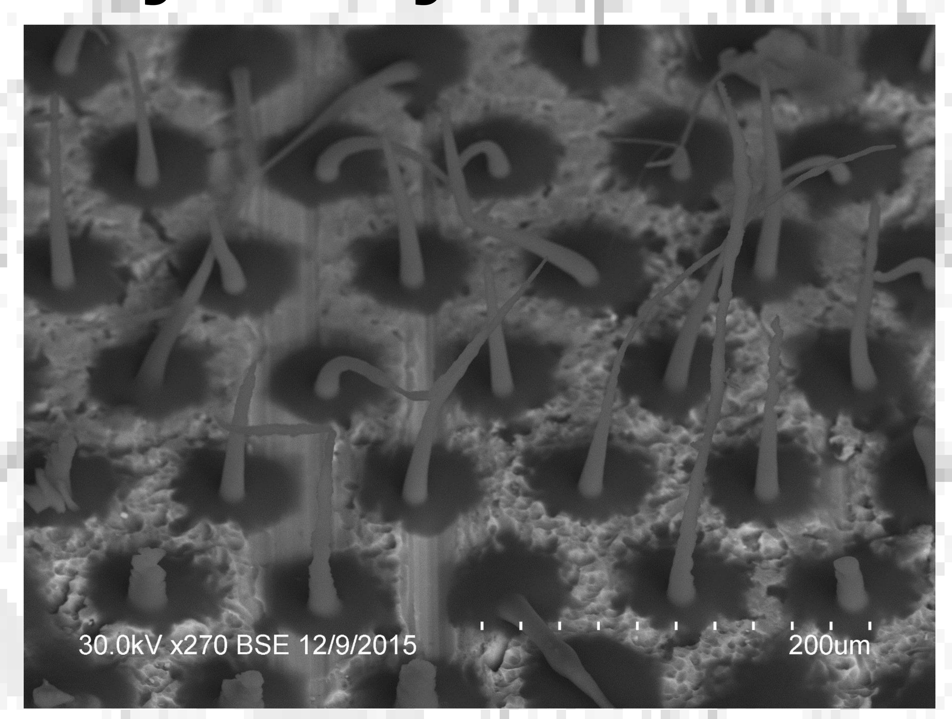
III. Self-aligned exposure by means of splitting primary X-ray beam



Exposure scheme with splitting the initial X-ray beam



8 mm thick SU-8 layer successfully treated by deep X-ray lithography



Needle-like microstructures on bottom of the resist layer, produced by the intersection of splitted X-rays

Acknowledgement

The part relating to microstructuring was performed at the shared Siberian Synchrotron and Terahertz Radiation Center (CU SSTRC) on the basis of the VEPP-4 - VEPP-2000 complex at BINP SB RAS, using equipment supported by the Ministry of Education and Science of the Russian Federation project Number RFMEFI62119X0022.
This work in part of mosaic lens creation was supported by the Karlsruhe Nano-Micro Facility Grant Number 2018-019-0021370.
This work was also supported in part by the Ministry of Education and Science of the Russian Federation Grant Number 0237-2019-0001.

Conclusion

We have presented the further development of the deep X-ray lithography technique in terms of the formation of combined microstructures with a high aspect ratio. Dose variation through the use of attenuators of various thicknesses and the splitting of the X-ray structuring beam can give new properties to the formed microstructures.

Litherature

1. LIGA and Its Applications, Ed.V. Saile, U. Wallrabe, O. Tabata, J G. Korvink, 2008, Wiley-VCH Verlag, Weinheim.
2. V.Nazmov, E.Reznikova, M.Boerner, J.Mohr, V.Saile, A.Snigirev, I.Snigireva, M.DiMichiel, M.Drakopoulos, R.Simon, M.Grigoriev, Refractive lenses fabricated by deep SR lithography and LIGA technology for X-ray energies from 1 keV to 1 MeV. AIP Conf. Proc., 705(2004)752-755.