Laser Targets from Thermonuclear Target Laboratory of Lebedev Physical Institute for International Experiments in Various Scientific Centers

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One goal – smoothing of laser intensity on target surface using different target constructions with low density materials:

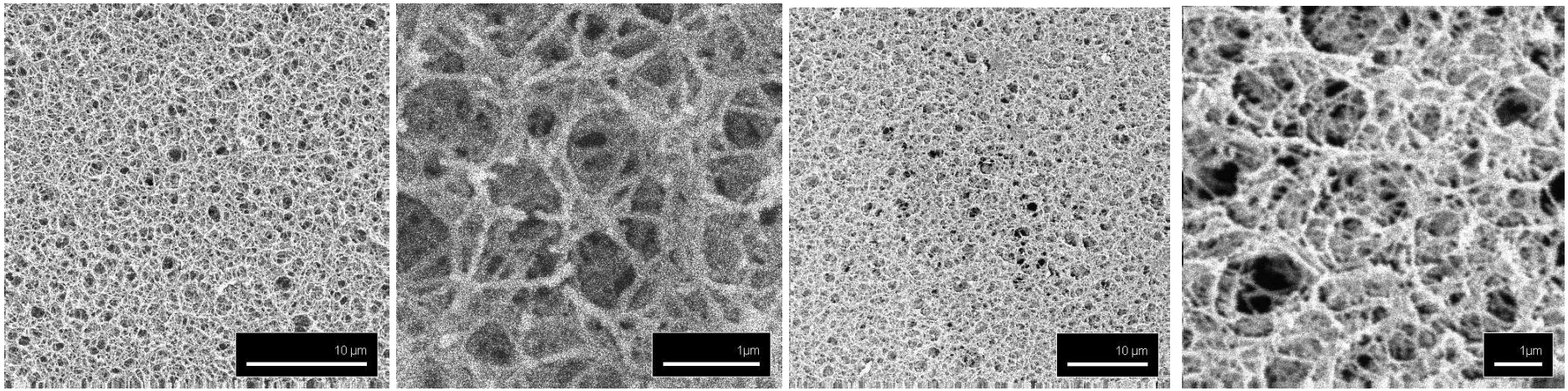
1. Method of heat-and-flow smoothing for non-uniform energy distribution (“Mishen” TRINITI, Russia; PALS Prague, Czech Repablic; LULI and LIL, France)
2. Method of dynamic plasma phase plate (“Iskra-5” VNIIEF, Russia)
3. High-Z nanoparticles dopant with different boiling temperatures for increasing uniform compression by soft x-ray radiation

New goals for low-density materials fabrication:

1. Multilayer structure with density ranging from subcritical (2 mg/cc) to 100 mg/cc for increased hydrodynamic efficiency of targets (“Canal”, LPI and “Luch” & “Iskra-5” VNIIEF, Russia).
2. Layers with density gradient for experiment on equation-of-state of the matter (“Canal”, LPI & “Mishen” TRINITI, Russia).
3. Concentration wave of high-Z nanoparticles dopant in low-density layer for increasing of efficiency targets, and/or for x-ray converter.

Targets from polymer TAC 3D-networks of different density

For Cu-loaded TAC aerogel, the ultra dispersive copper powder is used (average cluster size is 50 nm, specific surface is 23.6 m^2/g) and the silica-organic modifier is applied. Such treatment prevents the aerogel structure from deterioration that normally accompanies the loading procedure. Samples with the formed gel layer were bathed in methanol and supercritically dried using CO2 as usual. Doping the low-density material with high-Z clusters led to certain structure changes and roughening of the aerogel structure.



Similar structures for different densities were achieved. SEM images of TAC structure from the left to the right: 1st and 2nd correspond to10 mg/cc (bars equal to 10 and 1 micron respectively), 3rd and 4th – 5 mg/cc (bars of 10 and 1 micron respectively).

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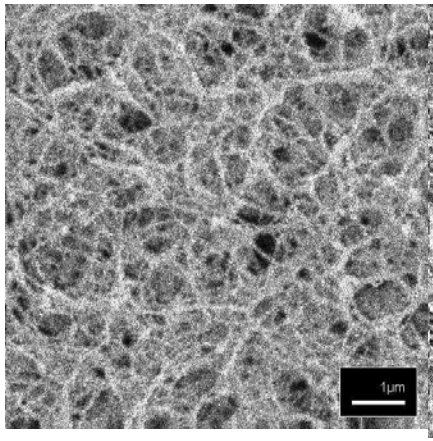
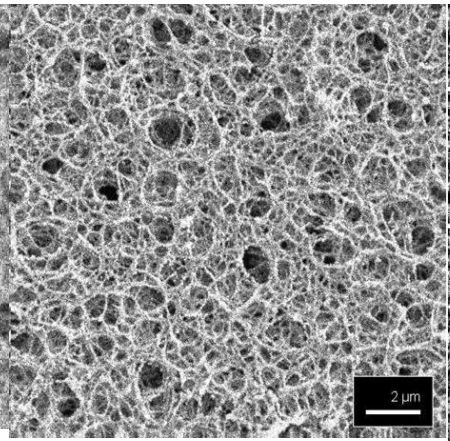
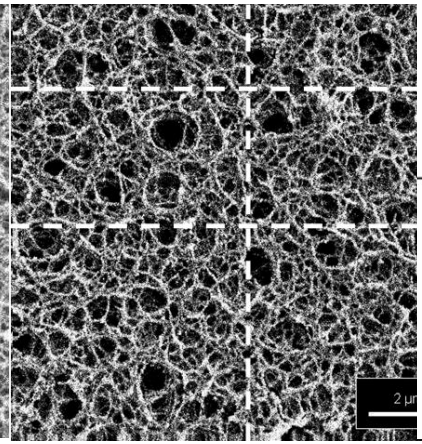
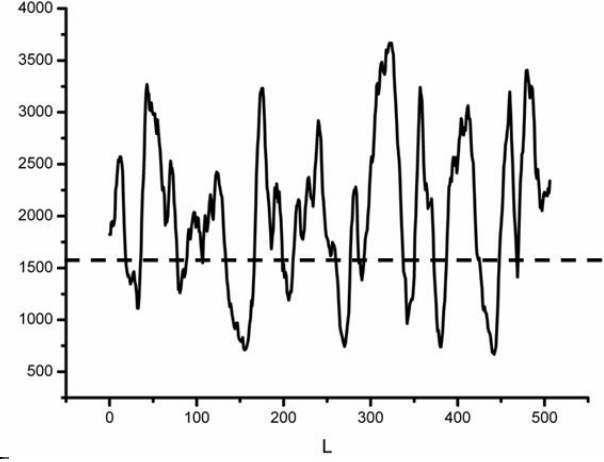
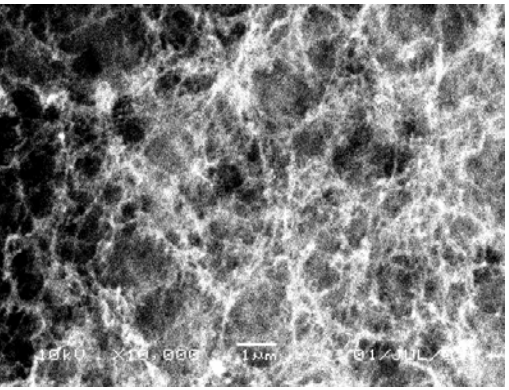


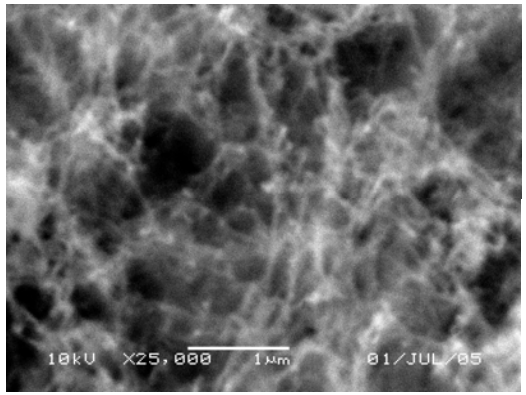




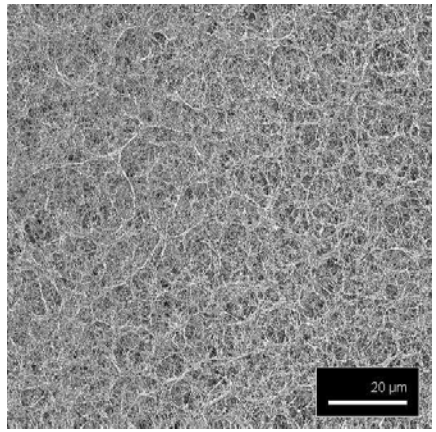


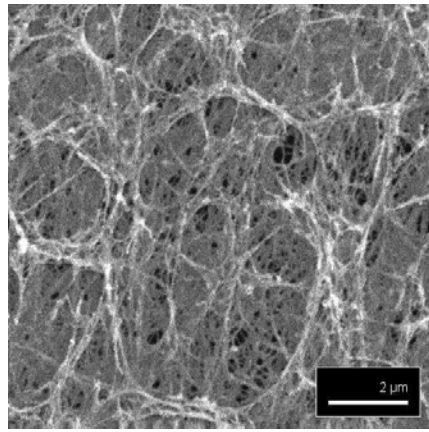
Left – SEM image of TAC 10 mg/cc. Scale bar 1 micron. The next 3 right pictures show computer procedure of picture analysis to measure the distance between fibers and average fibers diameter: first – initial picture, scale - 2 μm, second – contrast enhanced with line of measurement, third – intensity profile along line of measurement.





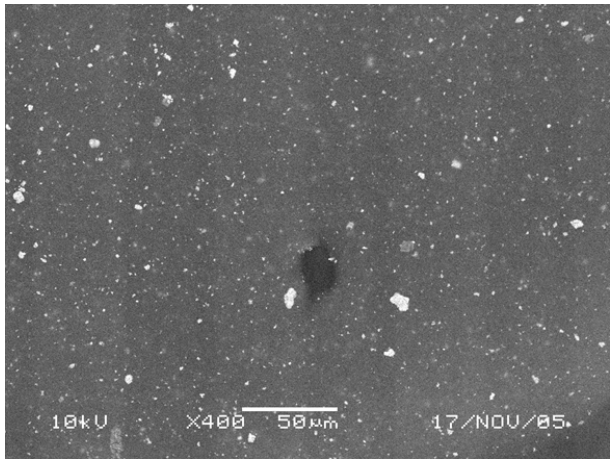
2 SEM images of TAC 5 mg/cc with carbon 20 nm coating. Scale bar is 1 μm.

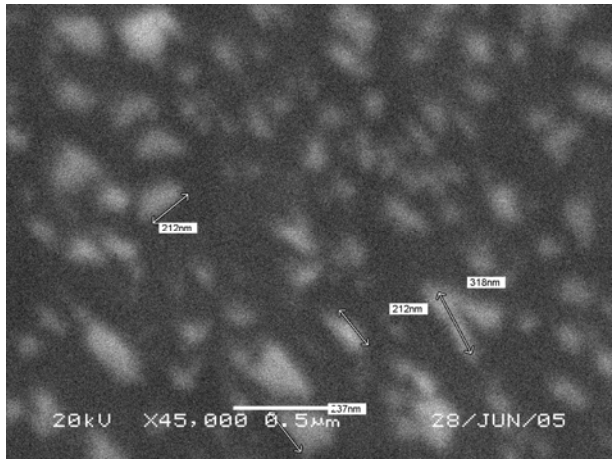


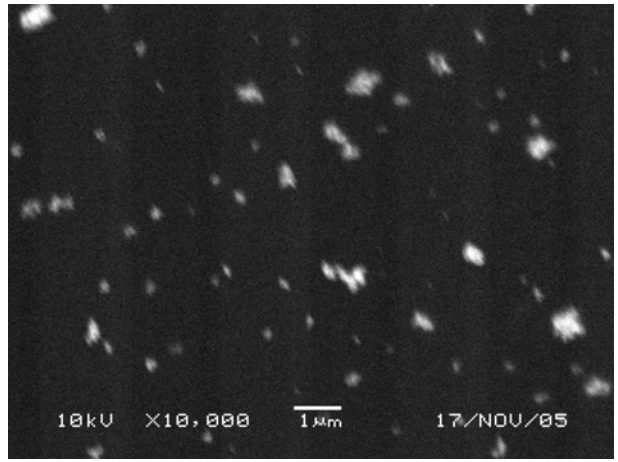


2 SEM images of TAC left - 2 mg/cc and right - 1 mg/cc with gold 30 nm coating. Scales are: left - 20 μm and right - 2 μm.

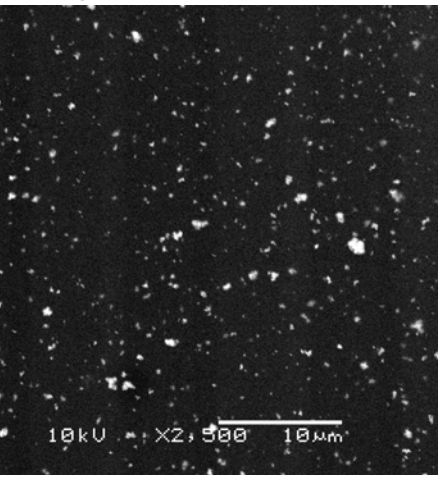
SEM monitoring of Cu-particles

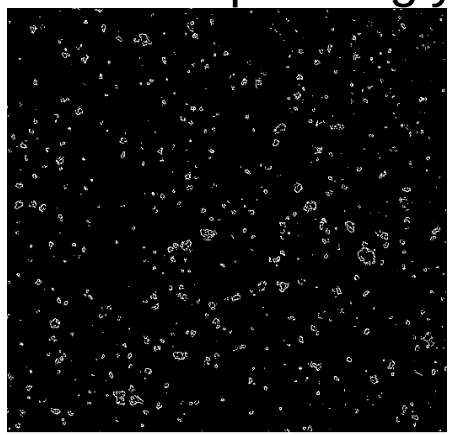






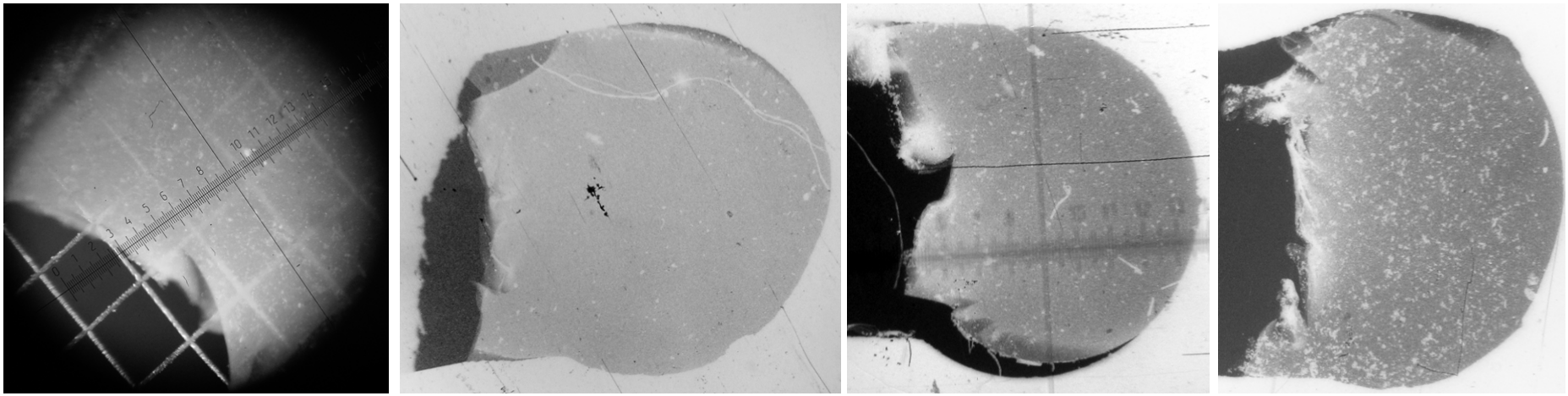
SEM in poor vacuum for submicron Cu particles and agglomerate visualization in X-ray self emission of Cu. TAC film+15wt% Cu. Bars equal 50, 0.5 and 1 micron correspondingly.





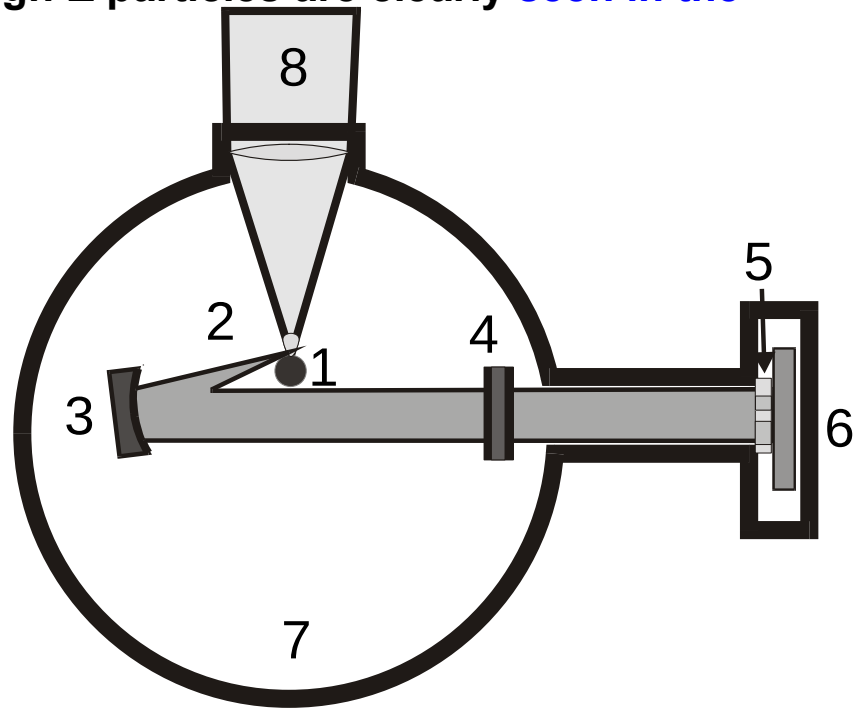
The images with no conductive material on the surface of the layer; dark area in center is due to damage of the low-density layer by electrons.

TAC film with Cu-particles in it (bar 10 µm): left – SEM picture, and right picture – numerically processed one for automatic particle and agglomerates counting. Software of LPI. **High-Z particles on the surface are clearly visible**

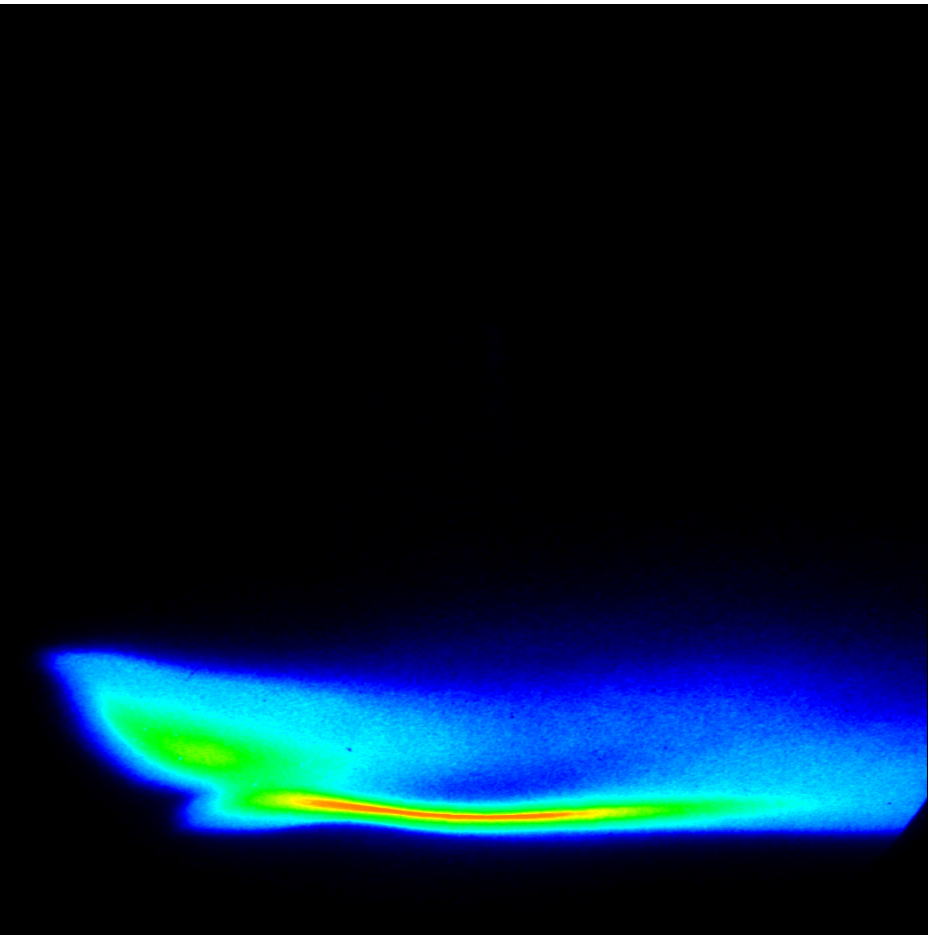


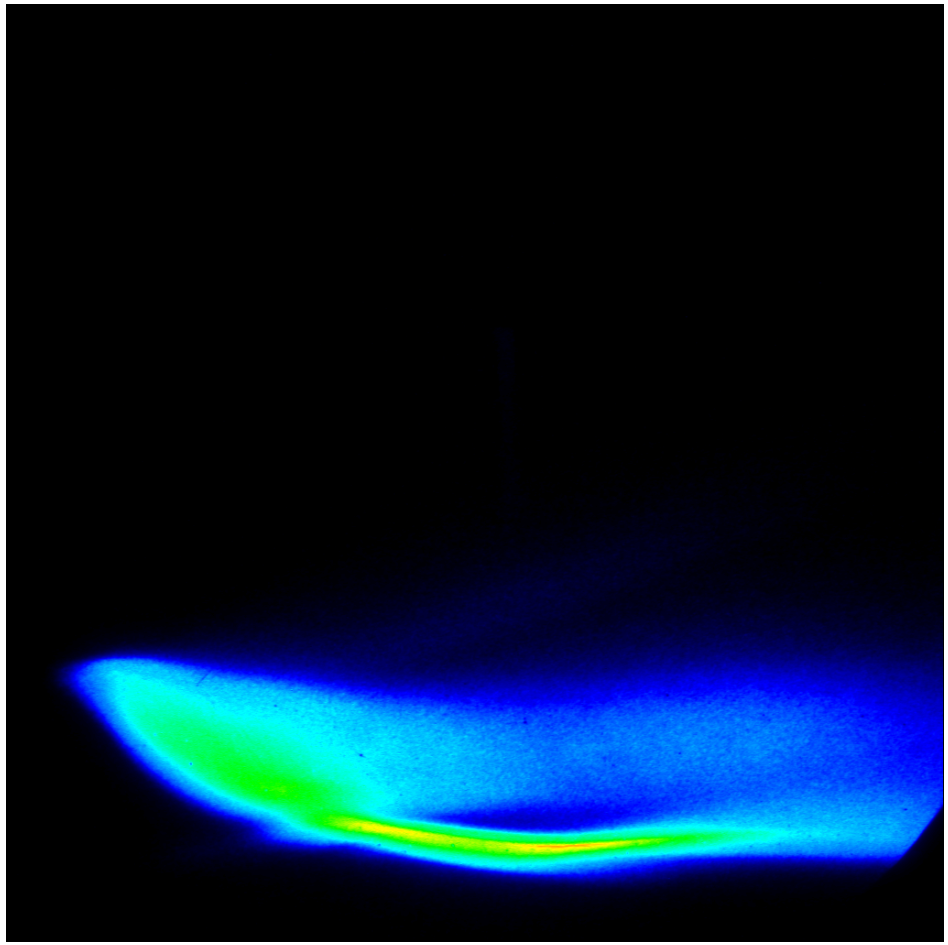
Left photo – optical view of TAC foam (10 mg/cc with 10wt% of Cu nano-particles) on the metal grid. 3 right pictures - soft X-ray transmission images of TAC with density 10 mg/cc. From left to right – pure TAC, TAC with 10% Cu by weight, TAC with 20% Cu by weight (70 μm between long scale marks). High-Z particles are clearly seen in the volume

Experimental setup for soft X-ray transmission imaging :
1- Massive renium target; 2- plasma cloud; 3- multi-layered X-ray normal-incidence mirrow *Co/C*; 4- *Sc/C* filter on the polyimide film; 5- sample under investigation; 6- X-ray photo-film UF-4 (Russian); 7- vacuum chamber; laser light (0.53 μm wavelength) .



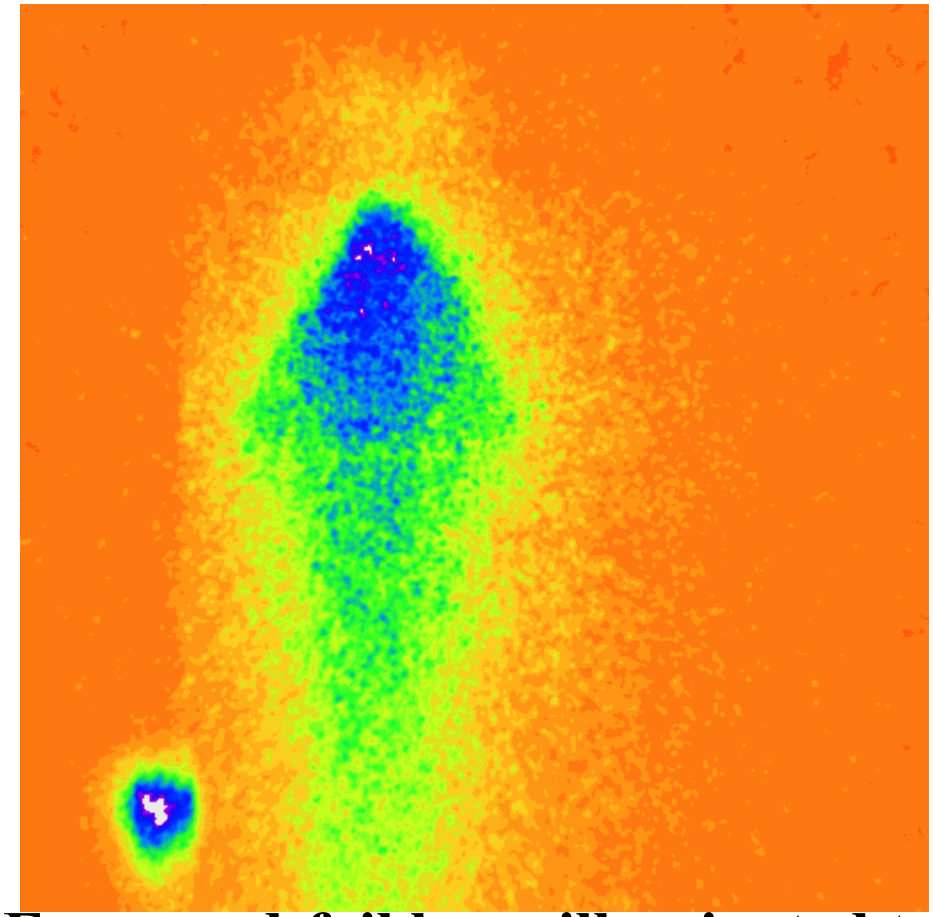
With stable laser performance and well characterized 3-D networks similar experimental data are reliably reproduced due to uniform target structure

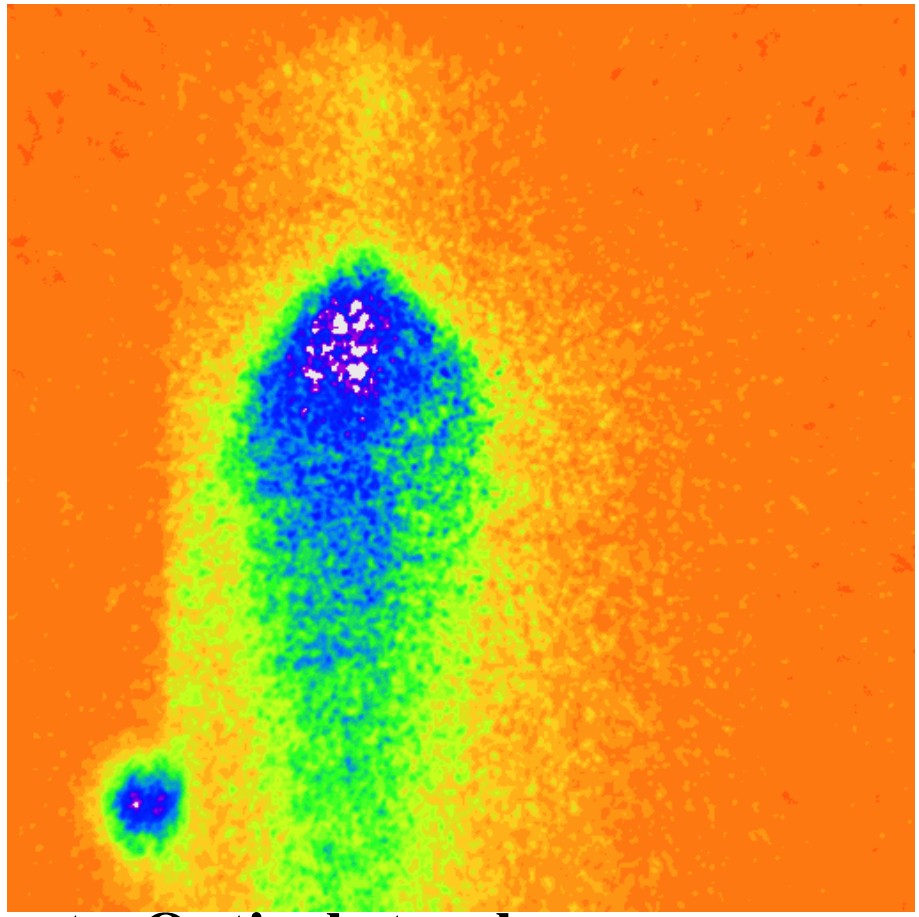




Shots #28233 and #28236 EL=165 J, TAC density 4.5 mg/cc, x-ray streak camera, time on the horizontal axis flows from the left to the right. The whole frame duration is 2 ns, laser light from above, the vertical spatial range is 2 mm. PALS iodine laser 3ω shots are reported from here on.

2006 PALS (Prague, Czech) experiments





Foam-and-foil laser illuminated targets. Optical streak camera images for TAC foams of 9 mg/cc 450 µm thick covered with Al-foil of 5 µm (done in 2005 and repeated in 2006) . **Time axis directed downwards, the total time recorded - 5.2 ns. Full frame in horizontal directions equals to 2mm spatial range. Separate spot on the left shows laser pulse delayed for 5 ns. Iodine laser 3ω shots 30225, E_L= 52,2 J and 30226 E_L = 50,5 J.**

Resume: **It is necessary to support the experimental researches of European Institutes collaboration in HiPER program**

The novel soft X-ray transmittance imaging based on laser illuminated x-ray source in conjunction with parallel beam selection by x-ray mirrors verified the technology rout capable of <1% density variations in the focal area.

Densities as low as 0.12Ncr were realized in illuminated TAC foams (optically transparent). Due characterization showed target-to-target repeatability in laser experiment on energy transport for similar target parameters. In undercritical plasma with varying dopant concentration the targets performance allowed to study numerous dependences via laser and target parameters.