EPSC Abstracts,
Vol. 4, EPSC2009-668, 2009
European Planetary Science Congress,

Hypervelocity impact simulation with the high-power Nd:phosphate laser facility

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The facility

Laboratory studies of hypervelocity impact and related phenomena, involving high-temperature sublimation, condensation and aggregation, are carried out with help of new laser facility SATURN. The system consists of three strongly synchronized laser channels with 30 J in pulse of 3 ns in first or second harmonics, 5 J in pulse of 30-50 ps, and 0.5 J in pulse of 150 fs, respectively. First beam is used for simulation of impactor interaction with solid surface, with local pressure on the interface reaching 1-50 Mbar. Two other beams are used mainly for diagnostic purposes, in particular for active sounding of ejecta during plume development, either immediately or after conversion of laser pulse into X-ray radiation on the auxiliary target made of high-Z material.

Preliminary experiments

In the preliminary experiment the channel for ns-long pulse generation was used

First harmonics beam at λ=1.06 μm with energy of 10 J and duration of 30 ns was focused onto a spot of ~0.3 mm with a caustic depth ~0.5 mm. The experiments were held in a 1200-liter chamber evacuated to 10^{-4} Torr, that prevented oxidation or reducing effect of the environment on ablation and sublimation processes.

Sample of mafic and ultramafic rocks were used to simulate differentiated planetary material at the stage of heavy meteoritic bombardement. Condensed material was collected on a Ni-foil screen installed across the path of plasma plume expansion at a distance of ~4 cm from the target. After the experiment the condensate film was studied by REM microphotography, mass analysis and other techniques.

The morphology of collected condensed material resembles lunar regolith, being substantially different from what was obtained with longer laser pulse (Figure 1). In particular, linear chains of interconnected spherules of ~20-30 nm in radius are formed, with chain length up to few micron.

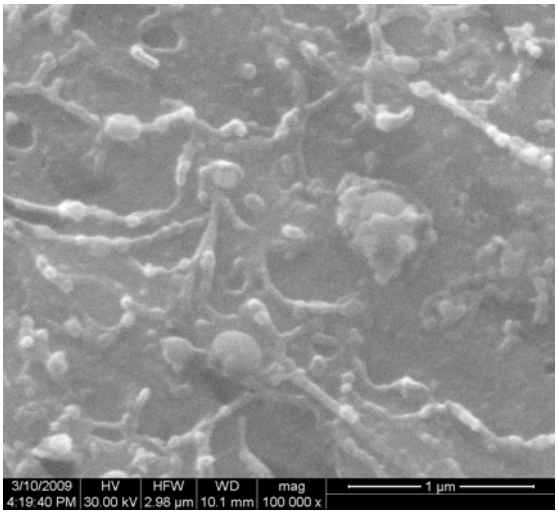

Figure 1. REM image of condensate material collected on Ni foil