HIGH-SPEED RADIOGRAPHY OF SHOCK WAVE COMPRESSION OF GYROID ALUMINUM

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Aluminum is widely used as a structural material in aircraft and rocket technology. Currently, 3D printers are widely used to build three-dimensional structures from aluminum. Samples printed on them are difficult to create in other ways.

To correctly calculate structures from such materials, it is necessary to know the equation of state taking into account possible shock loads.

The aim of this work was to study the shock compression of 3D structural (gyroid) aluminum using synchrotron radiation (SR).

The experimental setup is shown in Fig. 1. To create impact loads, a gun (*1*) is used with a small amount of high explosive (5–7 grams), which throws a striker (*2*) at a speed of 1–3 km/s. The sample (*3*) was a cylinder (20 mm in diameter, 15–20 mm in length), which was mounted on a plexiglass disk (*4*). The density of the sample varied from 0.9 to 1.7 g/cm^3. The strikers were made from copper, titanium, and aluminum, had a thickness of 4 mm and a diameter of 20 mm.

The SR registration plane (*6*) covers the distance from the gun to plexiglass disk. The entire assembly was placed inside the explosion chamber at the “Extreme State of Matter” station of the VEPP-4 storage ring (INP SB RAS) [1, 2].

High-speed X-ray radiography was performed using the SR from the 9-pole wiggler of the VEPP-4 accelerator, which operated in the 2–6-bunch mode with a duty cycle between SR pulses of 203 ns. The transmitted radiation is recorded by a high-speed one-coordinate DIMEX detector [3], which simultaneously records 512 channels with a resolution of 100 μm. Such a record constitutes one frame of the detector. After 203 ns, another frame is recorded; the detector can remember a total of 100 frames.

Figure 2 shows 100 consecutive frames of the experiment with a copper piston (along the *Y* axis). The frame numbers are converted to microseconds. The figure shows the movement of the striker (*1*), the original sample (*2*), the shock wave front in aluminum (*3*), and the contact boundary (*4*) between the piston and the compressed aluminum.

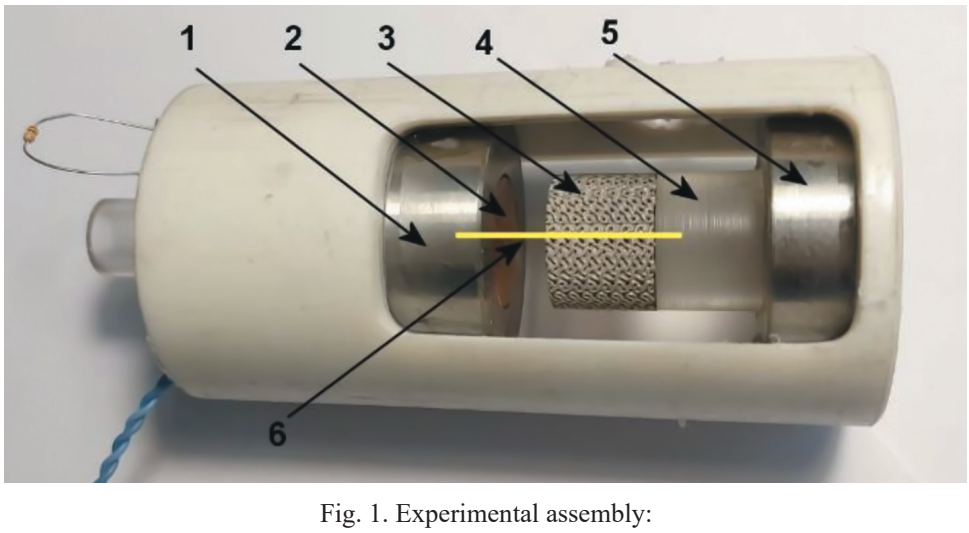

Fig. 1. Experimental assembly:

1 – gun, *2* – striker (copper, diameter 20 mm, thickness 4 mm), *3* – sample of printed structural aluminum (diameter 20 mm, density 0.91 g/cm^3), *4* – substrate (PMMA), *5* – metal disk, *6* – SR registration line

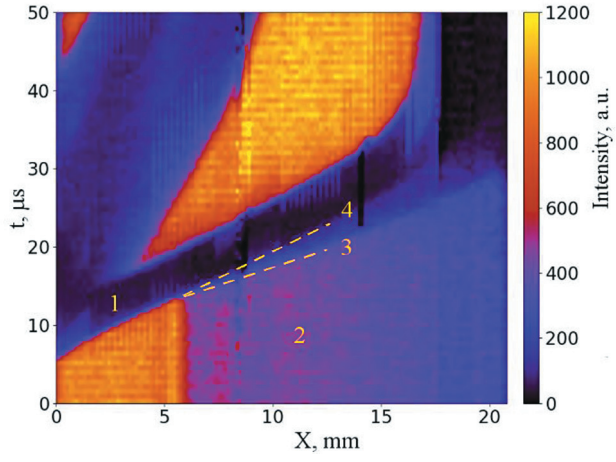

Fig. 2. X-ray movie of shock compression of aluminum:
1 – striker, 2 – initial sample (gyroid aluminum), 3 – shock wave, 4 – contact boundary between compressed substance and piston

The shock wave velocity (*3*) is $D = 1$ km/s, and the mass velocity (*4*) $U = 0.71$ km/s. The compression was $D/(D\text{-}U) = 3.4$. The same compression was obtained after calibrating the detector. Experiments were also carried out with titanium and aluminum strikers. D and U were obtained for gyroid aluminum in the range of shock wave velocities from 1 to 2.5 km/s.

The obtained data will be useful for mathematical modeling of shock compression of gyroid aluminum.

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