SUPPLEMENTARY INFORMATION

Dynamics and extreme plasticity of metallic microparticles in supersonic collisions

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Supplementary Figures

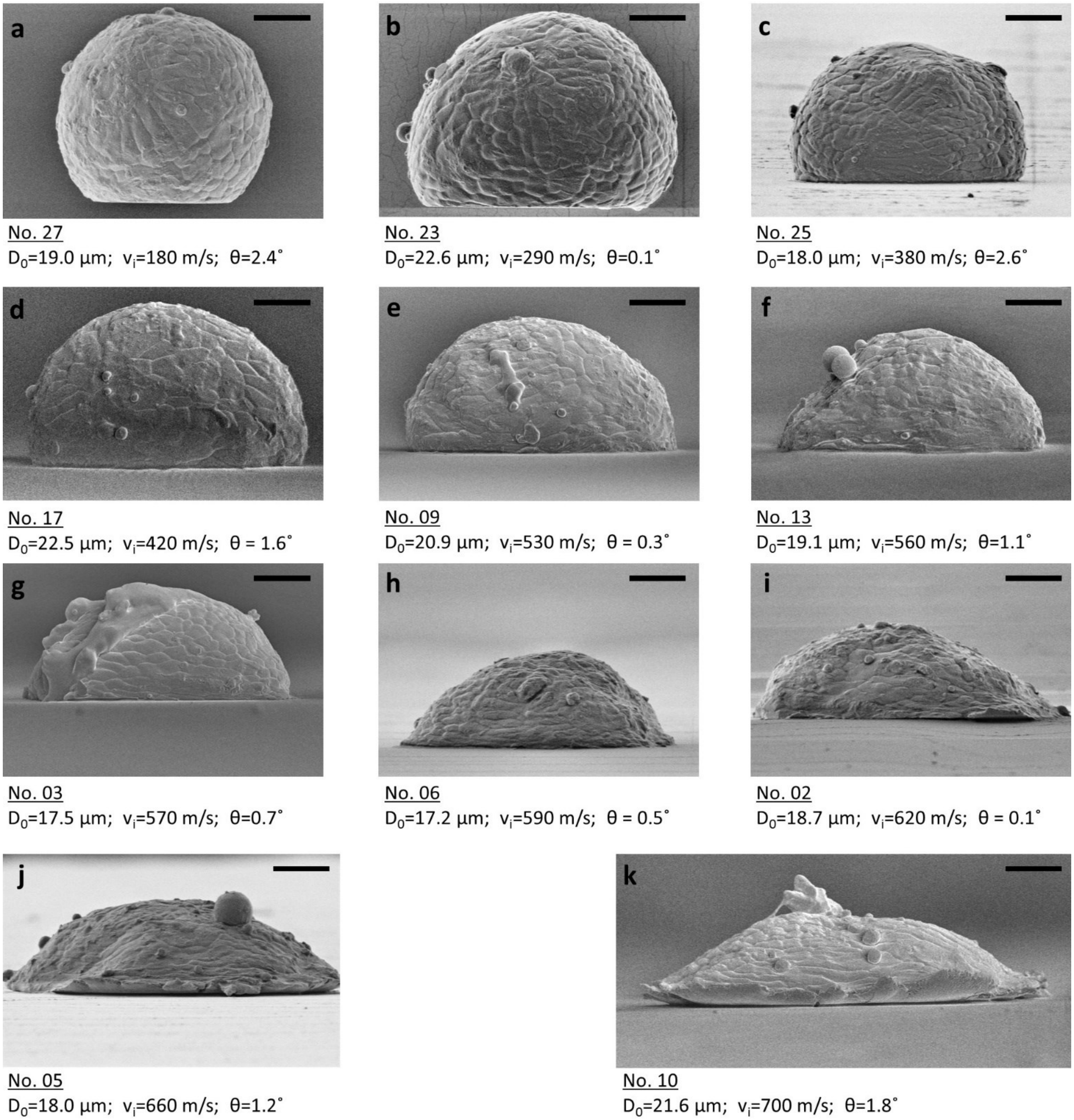


Figure S1 | Deformed aluminum 6061 alloy particles after collisions to sapphire surface. (a) – (k) Side view SEM images of deformed particles are shown with their initial diameters, impact velocities, and impact angles. All scale bars are 5 µm.

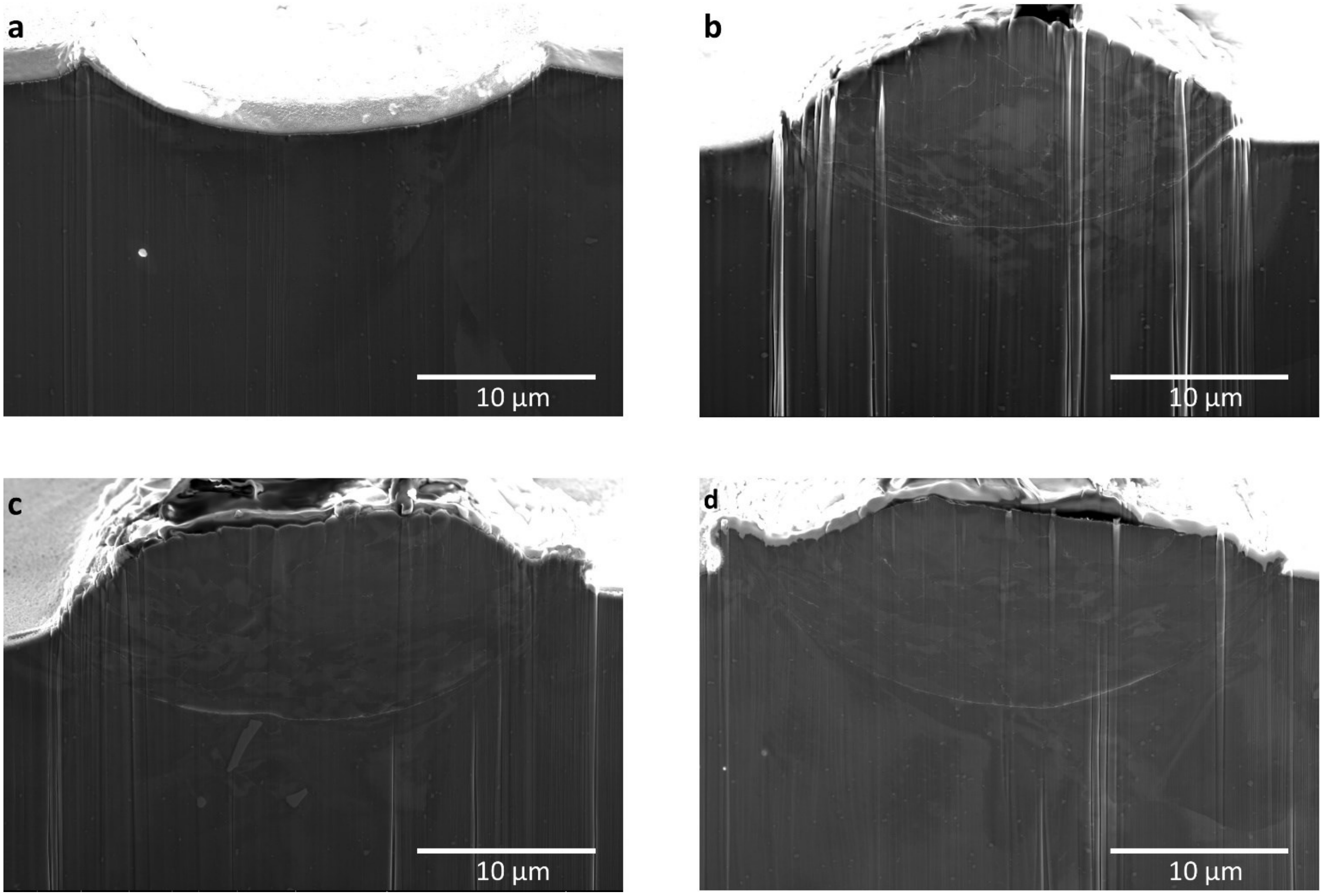
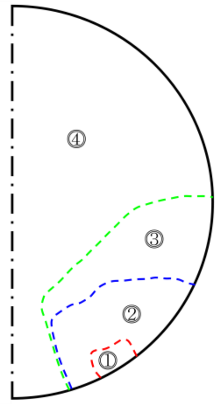
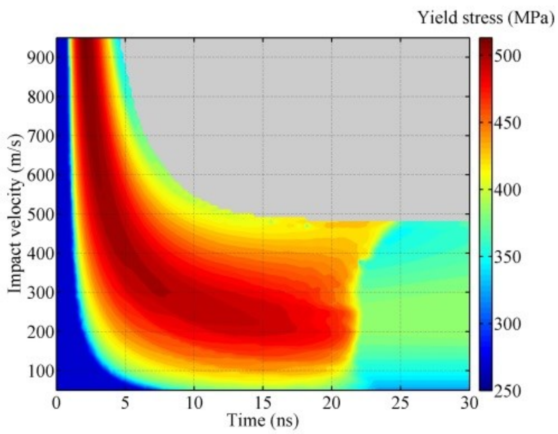


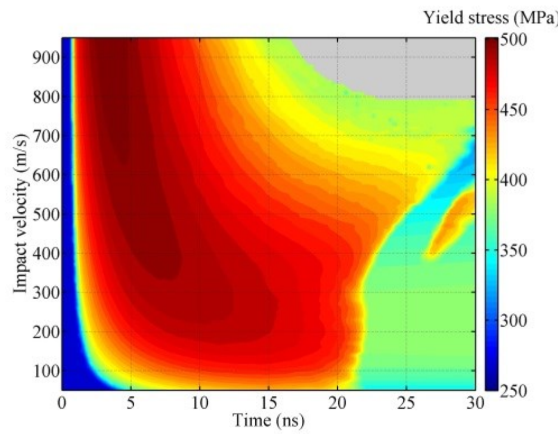
Figure S2 | Deformed aluminum 6061 alloy particles after collisions to aluminum 6061 surface. (a) – (d) The original cross-sectional SEM images of **Fig. 5e-h**.



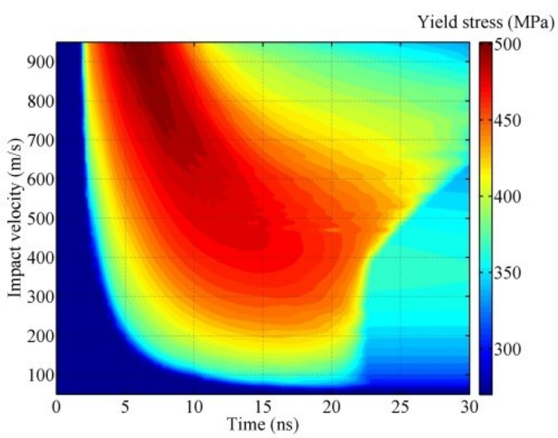
a)



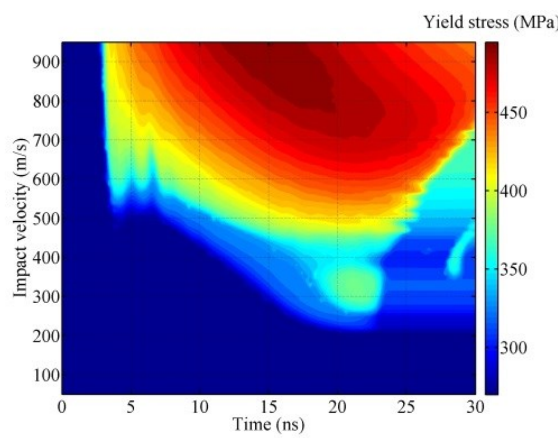
b) Region-1



c) Region-2



d) Region-3



e) Region-4

Figure S3 | Yield stress variation with time and impact velocity in the four characteristic regions of the particle.

Fig. S3a shows four regions in the particle that exhibit different material responses from this point of view. The material in regions-1 and -2 experiences significant softening during impact, where the instability occurs after 500 m/s in region-1 and 800 m/s in region-2 (**Fig. S3b, c**). In regions-3 and -4, the deformation is predicted to be less severe and no instability is observed, albeit in region-3 some softening is predicted above 700 m/s (**Fig. S3d, e**).

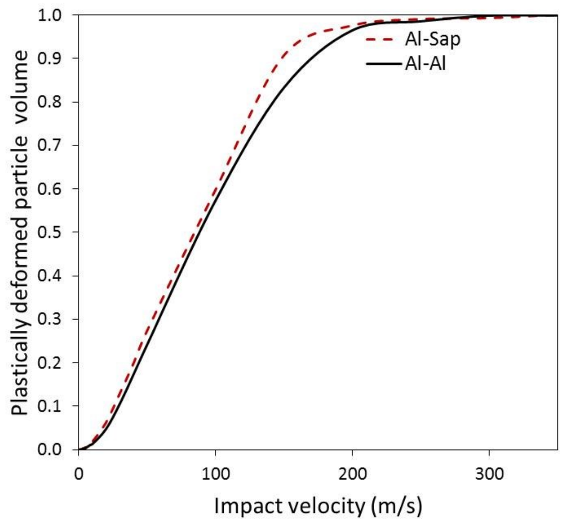


Figure S4 | Plastically deformed volume of the particle normalized with respect to the particle volume, shown as a function of impact velocity for both Al-Al and Al-Sap impacts.

Table S1: Material properties for the materials used in finite element simulations.

Properties	Parameter	Value		Unit
		Al-6061	Sapphire	
General	Density, ρ	2,700[a]	3,980	kg/m^3
	Specific heat, C_P	1,009[a]	755[a]	J/kg K
	Thermal conductivity	154[a]	33[a]	W/m K
	Thermal expansion	22.3[a]	4.6[a]	10^{-6}/K
	Melting temperature, T_m	925	–	K
	Inelastic heat fraction, β	0.9	–	
Elastic	Elastic modulus	69.11[a]	416[a]	GPa
	Poisson's ratio	0.331[a]	0.231	
Plastic (Johnson-Cook plasticity model)	A	270	–	MPa
	B	154.3	–	MPa
	n	0.239	–	
	C_1, C_2,	2×10^{-3}, 29×10^{-3}	–	
	[illegible]	597.2	–	
	m	1.42	–	
	Reference strain rate	1	–	1/s
	Reference temperature	293	–	K
Material failure	Failure strain	3	–	

[a] Temperature dependent properties. The values at room temperature (293 K) are shown. Data is taken from MPDB software.[1]

1 *Material Property Database ver. 7.99*. (JAHM Software, Inc., 2016).