Laser-assisted micro-patterning on NiTi shape memory alloys

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Abstract

Shape memory alloys (SMAs) are a class of active materials that can change their shapes reversibly with the change in temperature, and magnetic field, having a wide range of applications in aerospace, automotive, and medical sectors. Among SMA applications, morphing these materials at micro scales is of great interest. We report an advanced laser micro-patterning technique with the low-cost, quick, high-scalablity, and minimal environmental impact. Micro-patterns were obtained on $Ni_{50}Ti_{50}$ (at. %) SMAs using an Nd:YAG laser operating with 1064 nm wavelength at 10 Hz. Laser pulses at selected fluences were focused on the NiTi surface and generated pressure pulses of up to a few GPa. Scanning electron microscope (SEM) and optical microscope images showed that surface patterns with tailorable sizes could be obtained, where the depth of the patterns increased with laser power and irradiation time. Upon heating, the maximum depth recovery ratio of 30 % was observed. Recovery ratio decreased and stayed around 15 % when the amount of time and thus the indent depth was increased. Laser-induced shock wave propagation inside the material was simulated and the stress wave was shown to closely follow the rise time of the laser pulse to its peak value and initial decay. Rapid attenuation and dispersion of the stress wave were observed.