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Improvement of Residual Stress and Fatigue Properties in 3D-Printed Metal Materials by Laser Peening

Abstract
Additive manufacturing (AM) with metallic powders enables the direct fabrication of three-dimensional components from 3D CAD data. This technology has attracted significant attention in recent years because it allows the production of complex shapes that are difficult or impossible to achieve by conventional methods.
Among AM materials, aluminum alloys are of particular interest due to their low density and high thermal conductivity, making them promise for thermal management and lightweight applications in aerospace and automotive industries.
However, AM-produced metallic components often exhibit lower fatigue strength than conventionally manufactured ones, mainly due to process-induced defects.
To solve this problem, we focused on laser peening (LP), a surface treatment that introduces compressive residual stresses by generating high-pressure plasma with a high-power laser under a confining medium.
LP is highly controllable, reproducible, and capable of inducing stress relatively deep into the surface, which can effectively suppress fatigue crack growth and stress corrosion cracking, thereby improving fatigue properties.
In this study, a laser peening was applied to plate samples of an additively manufactured Al-Mg-Sc alloy, which has attracted attention as an aerospace material using an ultra-compact high-power laser.
After laser peening, residual stresses were measured using X-ray diffraction to confirm the formation of compressive residual stresses on the material surface. Then bending fatigue tests were caried out. The results showed that compressive residual stresses were imparted from the material surface to a depth of 200 μm. An increase in fatigue strength from 100 MPa to 175 MPa was also observed.

Biography
Mr. Yoshio Mizuta is a guest researcher of Department of Beam Physics, SANKEN, Osaka University, Japan. He is also a researcher at Nagoya Industrial Science Research Institute. One of his main research projects is the investigation of material processing technology using high power lasers and quantum beams. He is interested in laser peening technology as an application of laser-material interaction. His team has been developing laser plasma electron acceleration technologies, which uses electron plasma waves excited by the interaction of intense laser pulses and plasma to accelerate electrons and application.