Thermal sensing of AM components through electronics embedding in LB-PBF process

THERMAL SENSING OF AM COMPONENTS THROUGH ELECTRONICS EMBEDDING IN LB-PBF PROCESS

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The modified LB-PBF (laser beam powder bed fusion) process introduced [1] and patented [2] by the author allows to integrate discrete packaged sensors and/or customized electronics into the metal component during its additive manufacturing (AM) growth. This technology allows producing smart components suitable for networking, data sharing and IIoT (industrial interner of things) applications [3, 4]. The main advantages of sensors embedding in metal components are insulation from contaminations, protection against tampering, efficient transducer positioning, traceability of components, etc.

This paper reports the design and fabrication of samples made with steel (17-4 PH), aluminum alloy (AlSi10Mg) and Inconel (In718) with integrated thermal sensors (k-type thermocouple and PT100 sensor) and USHX electronic connectors. The process is conducted with the EOS270 and SLM500 systems.

The integration process is based on the growth stop and restart, which generally causes mechanical and metallographic singularities at the layer interested by the interruption. The printing parameters are preliminary optimized to eliminate the mechanical effect of the process interruption. This result is achieved by non-destructive tests at the interruption level made with optical and scanning electron microscopes (Fig. 1) and by tensile tests on samples with growth interruption (Fig. 2). Thermal treatments (solubilization, ageing, etc.) are also considered. In the next step, the optimized process parameters are used to build samples with embedded devices (sensors, connectors and cables). The patented technology includes a thermal shield that is used to protect the electronics against the laser heating when the micromelting process is restarted. The sample is built from the ground platform, and the housing of the internal sensors is created (Fig. 3). The process is interrupted, the temperature reduced into the printing chamber and the electronic devices are integrated. Then, the component growth is completed up to the last layer of powder micromelting.

The final result on some samples is reported in Fig. 4, as demonstrator of the technology reliability and suitability for IoT applications and advanced structural monitoring.

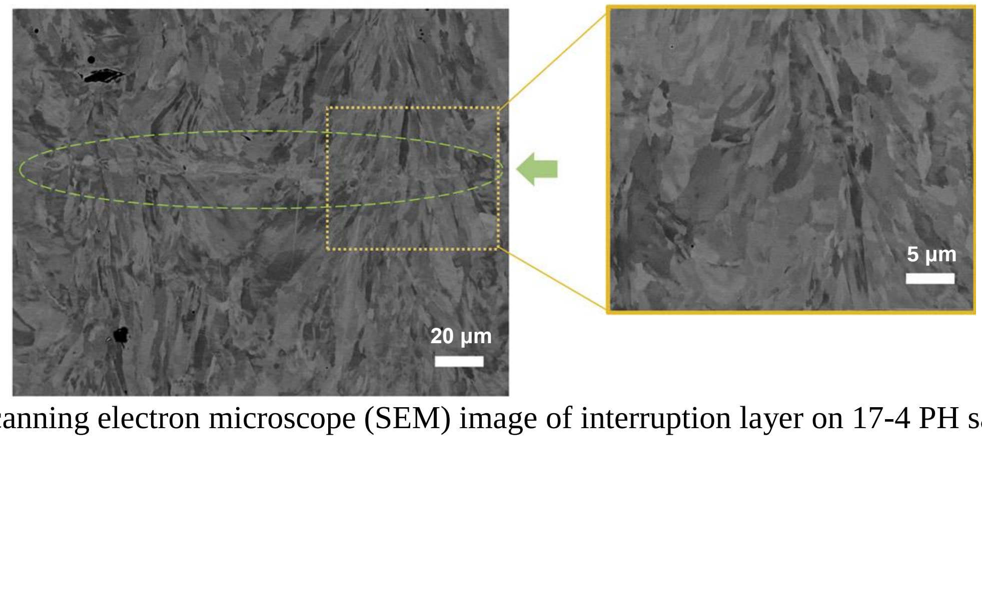

Fig 1. Scanning electron microscope (SEM) image of interruption layer on 17-4 PH sample.

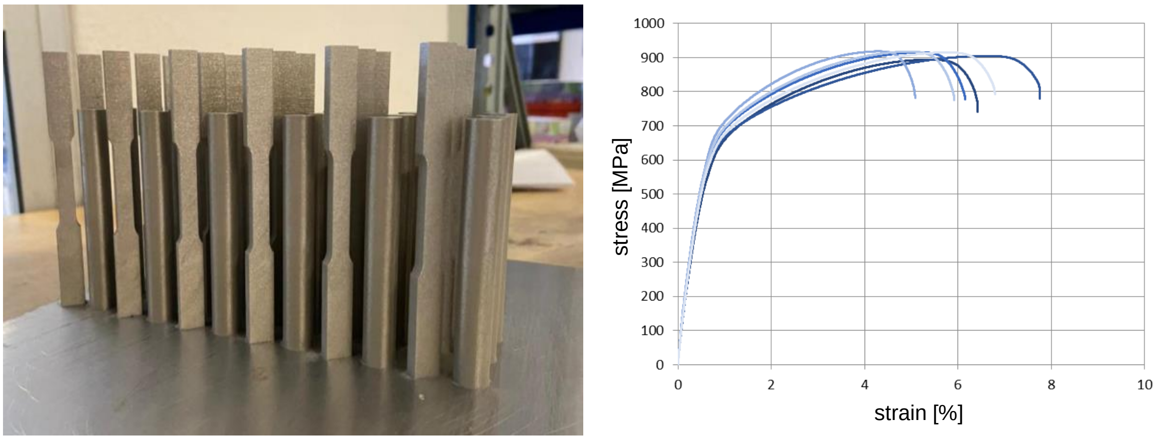

Fig. 2. Tensile samples in In718 and example of stress-strain curves of the as-built material with process interruption simulating the process for sensors integration.

Fig. 3. Internal view of the sample built with In718 and embedded PT100 sensor with ceramic connector USHX and electronics embedding operations.

Fig. 4. Sample released in final configuration with integrated sensor and external connection.

References

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