Processing SLM melt monitoring data for quality control

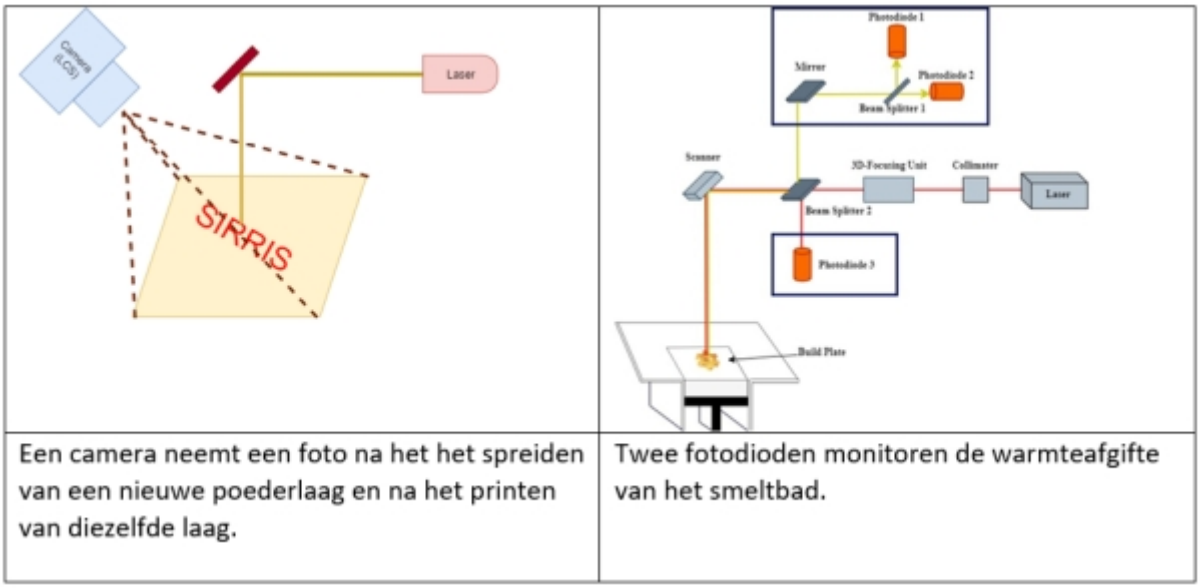
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Within the Enable project we accomplished the latest development in treatment of data coming from SLM melt monitoring for quality control of additive manufacturing parts.

The additive-manufacturing technology SLM (Selective Laser Melting) represents a major technological breakthrough and allows us to produce geometries that are impossible to manufacture with conventional technologies such as machining or foundry. The development of parts with this technology, especially in the aeronautical industry, requires the control of the quality of the manufactured parts: this includes the surface condition, defects such as porosities and cracks, microstructure, presence of interstitial spaces, etc.

Within the Enable Project, Sirris is working on how to use in-situ monitoring systems to easily detect these defects with non-destructive controls. For this purpose, we used our machines equipped with melt pool monitoring system and camera to record the manufacturing conditions (see: Figure 1).



Een camera neemt een foto na het het spreiden van een nieuwe poederlaag en na het printen van diezelfde laag.	Twee fotodioden monitoren de warmteafgifte van het smeltbad.

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Figure 1: In-situ monitoring equipment on the LBM machine at Sirris

Due to the enormous size of data obtained during monitoring, it is very difficult to process it visually for easy detection of process anomalies.

The Enable project first analysed the sensitivity of the melt pool monitoring (MPM) system to all kinds of print defects that may occur during printing. For this purpose, by varying the energy density, a range of the intensity of the weld pool was defined for these different defects. The reference data for AlSi7Mg0.6 was generated based on the geometrical location of print defects by linking melt pool intensity values to the defects Due to the varied heat conduction conditions on the molten surface and on the powder, all scanning vectors could be animated and related to the corresponding intensity values. This makes it possible to detect any deviation, as shown in Figure 2 below.

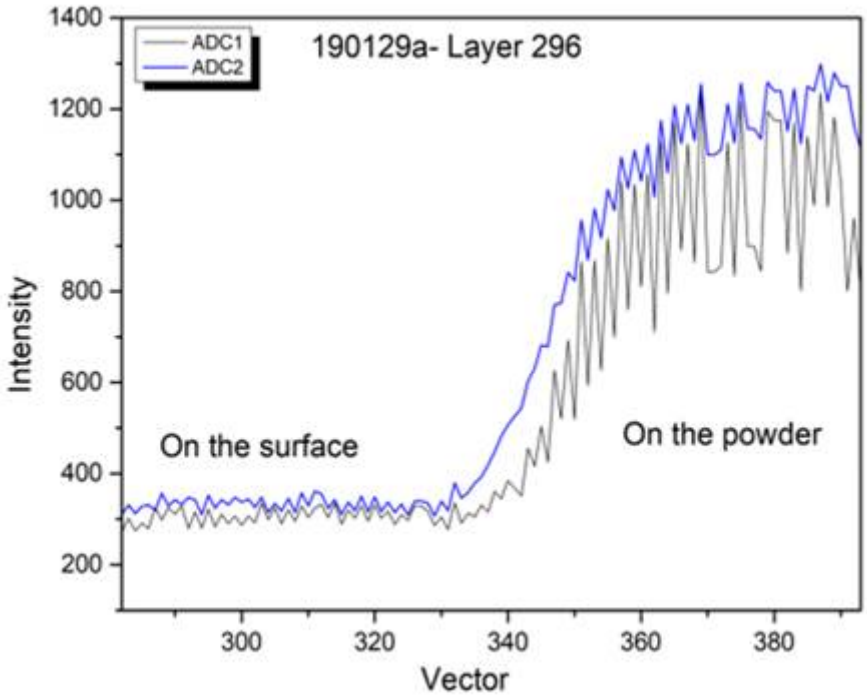


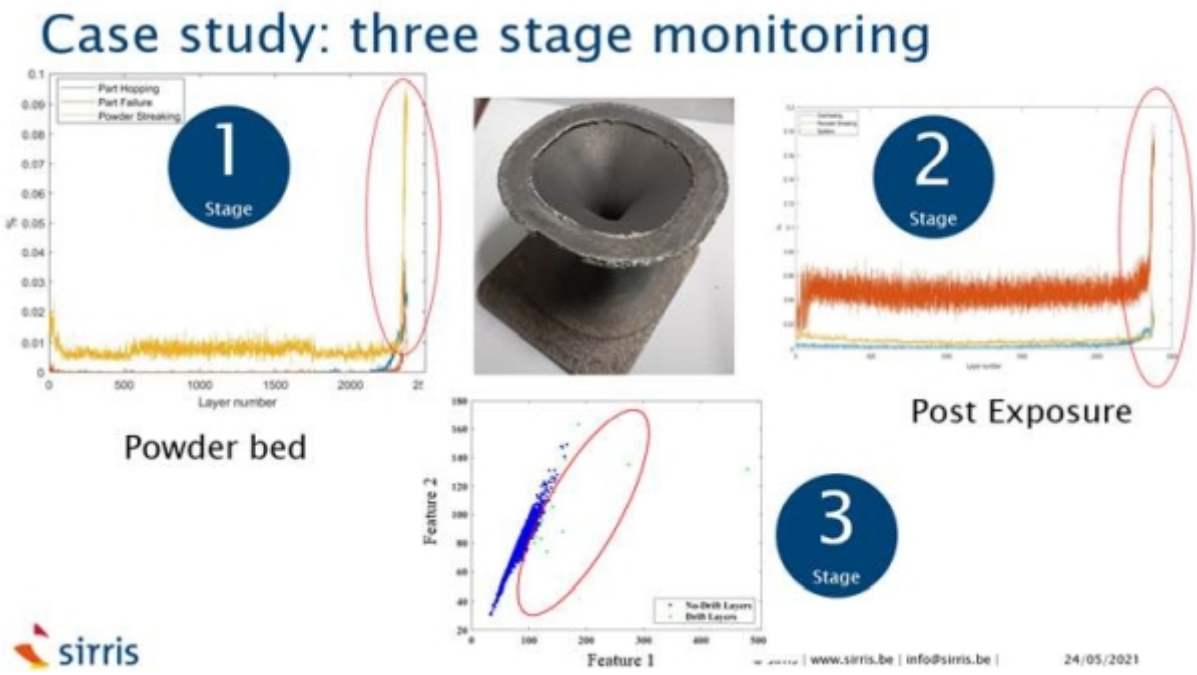
Figure 2: Example of an output file from MPM system for SLM showing the sensitivity of the signal to manufacturing conditions (scan on molten surface vs. scan on powder)

The final goal of this study is to reduce the use of non-destructive testing to identify print defects and to improve traceability of the defect location by melt pool acquisition system.

The study aims to monitor and post-process the in-situ data obtained at three different steps, i.e., before, during and after melting the powder with the laser. Pre and Post-Exposure images capture critical information regarding the powder-bed spreading and printed layer quality. Both images were automatically processed to detect anomalies, such as deformations of the part, collisions between the recoater and the part, and uneven powder distribution.

Similarly, the Melt Pool Monitoring data were analysed using machine learning algorithms.

Finally, a piece was manufactured as a benchmark to check the accuracy of the proposed algorithms.



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Figure 3: Automated anomaly detection using machine learning, applied in a case study on a benchmark piece

It was noticed that the algorithms successfully predict the anomalies and a correlation between defect detection via the 3 types of data analysed has been established.

Thanks to this kind of research project, Sirris is still increasing its competence in order to better guide industrials in understanding additive manufacturing processes.

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