

SPAT-TRAK™ SPATTER TRACKING SENSOR

The AMSENSE spatter tracking camera system is an add-on module featuring a 2 MP silicon-based CMOS camera configured to operate at 150 fps. The camera is mounted in one of the sensor viewports above the build chamber, providing a field of view to capture the entire build plate. The camera settings ensure that the only visible entities in the resulting frames will be the meltpool and any hot (bright) material in the general vicinity of the meltpool such as particle ejecta. The camera is also filtered to protect the sensor from laser radiation and reduce its spectral sensitivity to NIR emissions.

WHAT DOES IT DO?

The spatter tracking sensor is primarily designed to image the meltpool and adjacent hot spots and ejecta. An analysis plug-in is included as part of the module. This tool analyzes each incoming frame, crops the image to center the meltpool within the frame, automates the detection of a spatter event, highlights the meltpool and any spatter in the image, and writes out an HDF5 file containing structured data capturing each spatter event’s position, duration, distance traveled, and size. The plug-in is GPU accelerated to ensure that the data are processed as the frames come into AMSENSE and the results are immediately available. All the raw image data are also available to end users for in-processing or post-processing via user-developed plug-ins or other analytical tools, as available. The resulting images and accompanying statistics can then be used as a tool to assess overall process stability, analyze outliers and defects, and enable other research and applications development objectives.

SPATTER CAPTURE

An example of a detected spatter event is shown in Figure 1. The object detected with red outline is the meltpool while the blue circle highlights a detected spatter event. The spatter is automatically identified and tagged with location coordinates in the image pixel space, which is then registered in the resulting output file.

The pixel values could be used to register the location of the event in the coordinate frame of the build through either manual registration or homography techniques. Such coordinate transformation techniques are in development under active research efforts (results to be included as free module upgrade to users, as available), and users have capability to implement their own techniques as well.

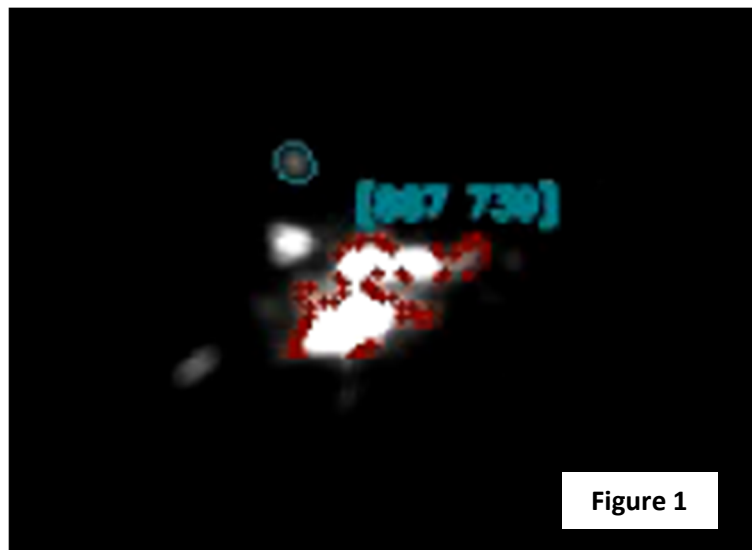
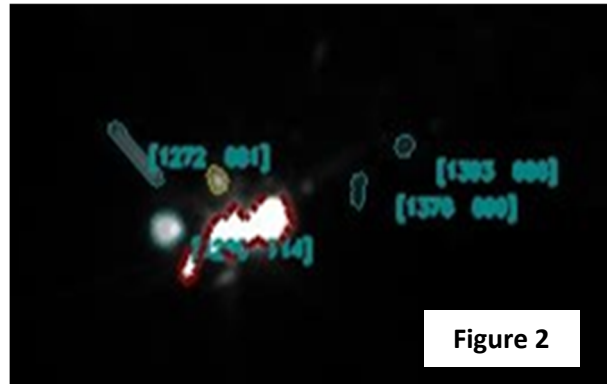


Figure 1

MULTIPLE EVENTS

The spatter tracking system is capable of handling as many spatter events as are present in the image frame. In Figure 2, four ejecta are detected in a single frame. The multidirectional nature of these events is captured in the resultant data file. These spatter events may last as short as a single frame, but frequently persist over several frames and move slowly relative to the melt pool itself.



USE CONSIDERATIONS

Like other sensing techniques, there are many possible activities which would benefit from the availability of spatter data. One obvious activity is process development. Typically, spatter is an indicator of LPBF process instability, inadequate process parameters, or poor materials quality. As such, a primary goal of process development is generally to reduce or eliminate spatter events. The AMSENSE spatter tracking sensor with associated analytics thus provides valuable data that may be used in either a qualitative or quantitative (statistical) analysis of process control. It can also reduce the number of samples to be evaluated for parameters development by enabling the identification of the most unstable specimens and focusing inspection efforts on likeliest specimens to produce quality material.

Spatter tracking may also be used in applications development by identifying areas of the build with a high number of spatter events, thus indicating a need for reorientation or modification of process parameters (either globally or specific to the regions of concern). Spatter tracking thus becomes part of the AM application engineer's toolset to identify and address processing challenges, enabling a more rapid development cycle from conceptual AM part design to production.

Once in serial production, spatter tracking may continue to be useful to assess whether the process is becoming unstable, feedstock is performing as expected, or a truly anomalous event has occurred that could produce inclusions in the final part that might not be detectable by traditional NDE techniques. As such, spatter data may be an important element of a part's "digital thread", particularly for parts intended for the most demanding applications such as aerospace, defense, and medical. The HDF5 output data file is formatted to facilitate simplified post-build analysis of the detected spatter events and also record the build information, providing a pedigreed data set containing not just the analytical results but also the build parameters and other meta data associated with the build.

FUTURE OUTLOOK

Research is ongoing to improve the AMSENSE spatter tracking capabilities and develop and demonstrate useful applications for it for defense and industry needs. R&D users have the opportunity to leverage the spatter tracking sensor and resulting data sets to develop their own process monitoring and control tools and techniques for basic and applied research, technology development, and AM applications.