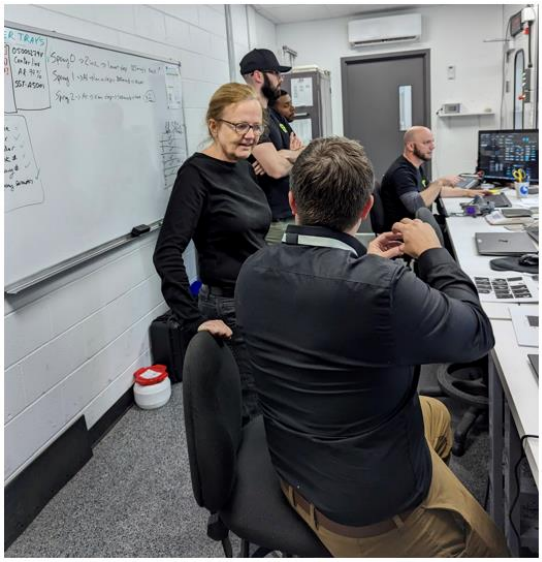
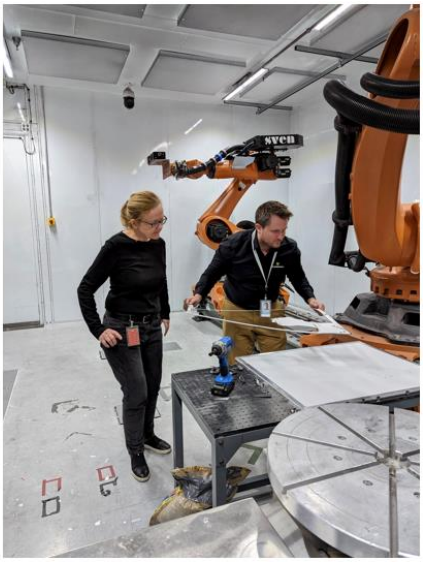
How the Intertwining of Art and Technology can Propel Innovation.

Christine Fitzgerald is an award-winning Canadian photo-based artist who is known for using uncommon methods to create unique physical objects from photographs. Christine approached professor Bertrand Jodoin, the head of the University of Ottawa Cold Spray Lab, to collaborate on a unique piece of artwork produced using cold spray. Cold spray is a metal additive manufacturing technology in which metal particles are accelerated through a converging-diverging nozzle to supersonic velocities. During impact, the kinetic energy of the particles is transformed into plastic deformation and heat, resulting in mechanical and metallic bonds. Dr. Jodoin quickly realized that the scale of the artwork exceeded the capabilities of the university laboratory space and reached out to the cold spray specialists at PolyCSAM, the Polycontrols metal additive manufacturing hub. PolyCSAM is a world-class, cold spray, hybrid additive manufacturing demonstrator facility integrating advanced surface preparation techniques, material deposition, in-situ robotic machining & surface finishing, heat treatment, and data analytics/machine learning-based process control.

The artwork that was chosen was an image of a Crinoid Fossil found on Anticosti Island, originally printed using “Tri-colour Gum Bichromate on Palladium” for a previous exhibition. Dr. Alexandra Nastic, a post-doctoral fellow at the University of Toronto who obtained here PhD from the University of Ottawa, digitized the image into a series of 23 overlaying stencils. The digital stencils were then laser cut into 1/16” stainless steel sheets, creating robust masks that could handle the harsh cold spray conditions. The substrate was a ¼” thick aluminum 6061 cut to 26”x32”.





At PolyCSAM, many different metals were deposited as samples to create a colour pallet for the artist to work with. It was decided that we would be using 6 metal powders, each with a distinct shade of grey. The thickness of each layer, determined by the artist, could be controlled by the velocity of the spray gun. Shims were adhered to the back of the masks and adjusted between sprays to ensure a consistent standoff between the mask and the substrate, as

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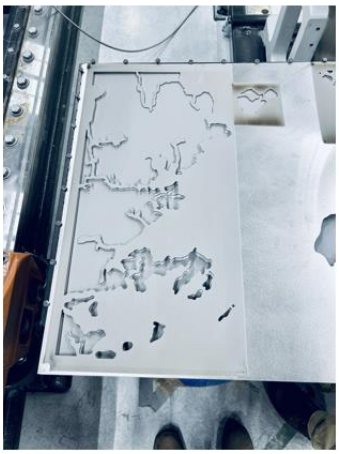
the artwork grew between layers. The rigid masking technique was found to be successful, leaving clean sharp edges, something that is not common in cold spray additive manufacturing.

The first roadblock that we encountered was delamination of the base layer on the substrate. The adhesion of this layer on the bare substrate was adequate at first, but as subsequent layers of different materials were deposited on top, the accumulated residual stresses would result in delamination at the substrate interface. This was overcome by enhanced substrate preparation and switching the base layer feedstock powder to one that is known to produce higher adhesion strengths. Delamination between deposited layers did not prove to be an issue.



The second challenge we faced was when layering different combinations of materials together. Cold spray is an aggressive process that requires violent particle impacts to ensure bonding. The impact intensity required for adhesion varies based on the material properties. In this work, materials with very different mechanical properties had to be layered on top of each other. This caused an issue when spraying hard materials onto soft materials. In such cases, the hard materials would erode the soft materials and would not deposit until the softer layer was completely removed. Through testing, a combination matrix was created in which each metal was sprayed onto each other to determine which combinations could be successfully deposited. From this, it was found that one of the metals could be used in any combination. Therefore, in any situation where an incompatible material sequence was required, a thin layer of this intermediary metal was deposited between them as a sort of bond coat. Developing

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this experience in layered materials is beneficial for the future, especially with the growing interest in functionally gradient materials produced through cold spray.

With the expert guiding hand of the artist, each layer was deposited to the desired thickness and a blank slate of aluminum slowly grew from abstract shapes to the intended vision. This unconventional use of cold spray has produced a unique piece of artwork that seamlessly blends innovative additive manufacturing technology, photography, and art.

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