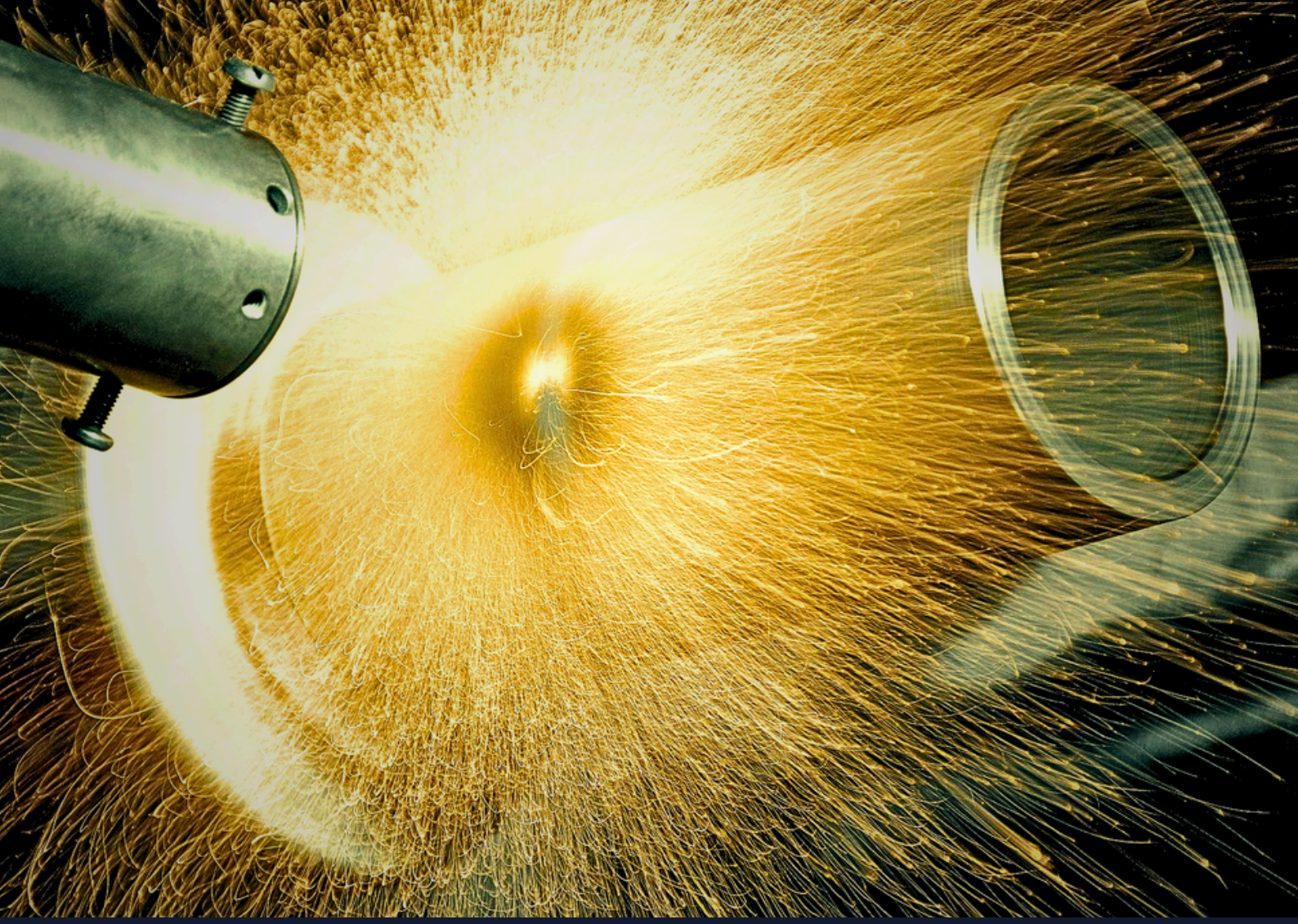


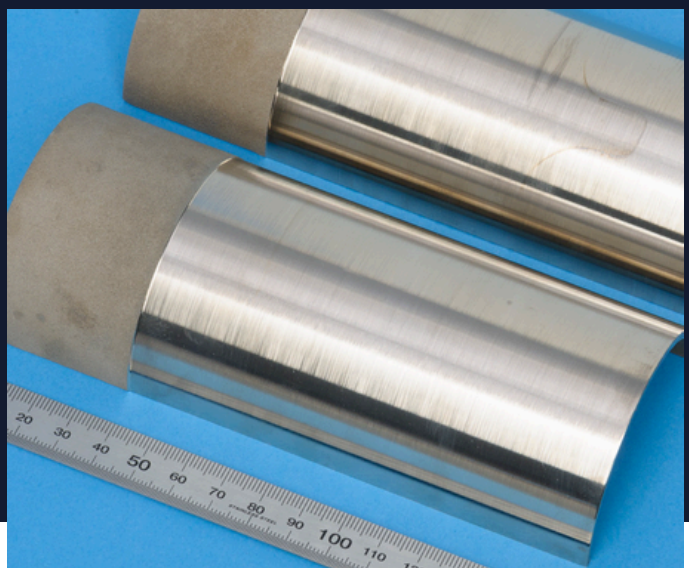
Cold Spray Technology Centre

TWI

TWI-Global.com

What is Cold Spray?

Cold spray technology is an advanced solid-state material deposition process where fine powder particles are accelerated to supersonic speeds using a preheated high-pressure carrier gas and projected onto a substrate. Upon impact, these particles undergo severe plastic deformation and bond to the substrate without melting, forming dense deposits for applications such as coatings, repair, and near-net-shape additive manufacturing. The bonding mechanism is similar to explosion welding and, ensures strong adhesion and minimal thermal impact on the substrate, preserving the material's properties and avoiding issues such as oxidation or thermal distortion.



Key Applications

Functional and protective coatings

- Enhancing wear, corrosion, or thermal resistance

Repairs and Remanufacturing

- Cosmetic and dimensional repairs restore components to their original specifications, with the potential to repair load-bearing, high-value parts without compromising strength

Additive manufacturing

- Produces near-net-shape parts at high deposition rates with minimal material waste

Multi-material and functional grading

- Enables multi-material builds with or without functional grading for bespoke applications

Key Advantages

Solid-state low-temperature deposition

Powder is applied at temperatures significantly below its melting point without needing an inert atmosphere. This process prevents oxidation and phase transformations, preserving the feedstock's microstructure, minimising residual stresses and distortion, and avoiding heat-affected zones

High density and material compatibility

Cold spray produces dense deposits and is compatible with a wide range of materials, including metals, ceramics, and polymers. This also enables deposition of multi-material and functional grading of material

Enhanced properties with thermal treatments

Suitable post-deposition thermal treatments can enhance cold spray deposits to match the properties of their wrought counterparts, improving mechanical strength and performance for demanding applications

System variability

Cold spray systems come in portable and fixed configurations, with 'low', 'medium', and 'high' pressure types differing in powder injection points. Each system offers unique advantages based on application needs

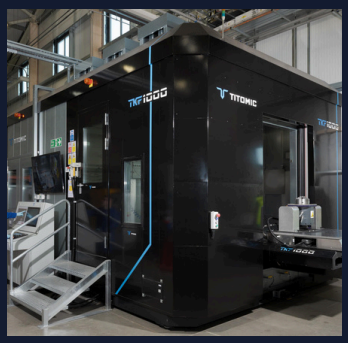
High design freedom, deposition rates, and scalability

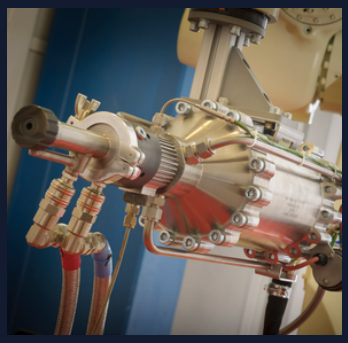
Cold spray technology provides extensive design flexibility, high deposition rates, and is highly scalable for various industrial applications

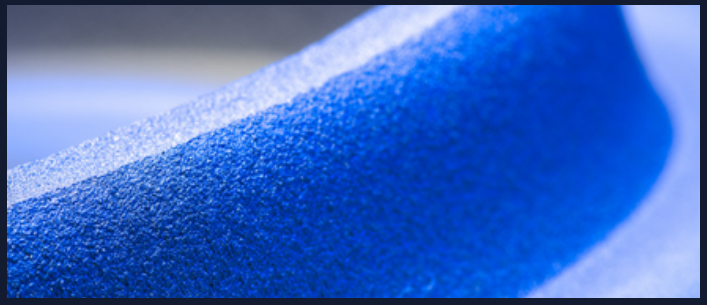
Cold Spray at TWI

TWI has been at the forefront of cold spray research and development for over two decades, carrying out projects for our Industrial Members and leading government programmes. So far, TWI has delivered over 60+ projects (~£8m) for its Member companies across various sectors, including aerospace, space, defence, oil and gas, nuclear, and medical implants. More than half of these projects have focused on aerospace and defence, involving materials like Al, Ti, Ni alloys.

As a globally recognised leader in cold spray technology, TWI delivers unparalleled technical expertise supported by state-of-the-art facilities and deep in-house knowledge across a spectrum of integrated disciplines. These include numerical modelling, thermal treatment, powder metallurgy, microstructural characterisation, non-destructive evaluation, and mechanical testing.







Cold Spray Equipment

TWI owns three cold spray systems and has invested in a large-scale spray booth so that development work can extend to prototype component scale. These systems include:

Titomic D523 portable low-pressure system

- A low pressure unit designed for manual and semi-automated application of ductile coatings, typically aluminium and copper blended with a fine aluminium oxide abrasive to aid coating adhesion and density. This uses compressed air as the process gas, and is capable of spraying at gas pressure of up to 6 bar, and gas temperatures of up to 600°C

Impact Innovations 5/11 high-pressure system

- A high pressure system capable of spraying at gas pressures and temperatures of up to 60 bar / 1000°C or 50 bar / 1100°C using nitrogen gas, and equipped with a single powder feeder. This system is installed within the large scale spraying facility and is mounted on a 6 axis robot and linear track that allows deposition onto large components, up to 7m in length and around 3m height, and has software for offline toolpath programming for complex toolpaths. This spray cell is also equipped with laser heating optics, that allow laser assisted cold spray (LACS) of challenging materials, where a laser is used to selectively heat a surface immediately prior to cold spray coating

Titomic TKF-1000 high-pressure system

- TKF-1000 is a top of the line, high pressure, cold spray cell, designed with additive manufacturing and production in mind. It uses an Impact Innovations 5/11 cold spray system, and is equipped with a dual powder feeder that allows co-deposition of materials for the production of metal-matrix composites or functionally graded deposits. This system is configured to spray using nitrogen and helium gas, with helium being used for extremely demanding applications where the application justifies the high cost of the process gas. The nitrogen supply is from a bulk liquid system, with sufficient capacity to spray for several days at a time

Core Research Projects

TWI's Industrial Members have exclusive access to the Members' Reports of the following cold spray research work to the value of over £600k which has been funded by TWI Industrial Members:

CRP REPORT TITLE	REPORT NO.
Cold Spray Deposition of a Powder Produced from a Beta Titanium Alloy	1163/2023
Adhesive-Free Bond Strength Test Method for Cold Spray Coatings	1127/2020
Cold Spray Systems for Nickel Alloy 718 Coating Deposition	1063/2015
Corrosion of Cold Sprayed Tantalum Coatings	1016/2012
Preliminary Evaluation of Spray-Formed Ti and Ti Coatings Prepared by Cold Spray	0995/2011
Cold Spray Technology Update and TWI Facility Installation	0947/2010
Preliminary Evaluation of Metallic Coatings Deposited using the Cold Spray Process	0787/2004

Cold Spray Training

TWI offers bespoke cold spray training. Presented over two days, the course is intended for materials and design engineers who are considering the use of cold spray as a functional coating, repair, and/or additive manufacturing technology. Course attendees will gain a detailed appreciation of where cold spray fits into the wider field of thermal spray technology, surface engineering and coating processes.

Industrial Mentoring and Sponsorship of PhD Students

TWI have been sponsoring PhD research projects with different academic partners through TWI's National Structural Integrity Research Centre (NSIRC), on the following topics:

Ongoing PhD projects

- Kwadwo Asamoah, Portable Cold Spray for Repair of Light Metal Components, Coventry University (2024-2028)
- Parcelino Sudigdo, Laser-Assisted Cold Spray of In718 for Structural Repairs, University of Nottingham (2023-2027)

Completed PhD projects

- Bakir, Ali (2025) Structural Integrity of Cold Spray Repaired Aluminium Alloy 7075, PhD Thesis, Coventry University
- Sabard, Alexandre (2020) Solution Heat Treatment of Gas-Atomised Aluminium Alloy Powder for Cold Spray. PhD Thesis, University of Nottingham.
- Boruah, Dibakor (2020) Structural Integrity Assessment of Cold Spray Additive Manufactured Titanium Alloy Ti-6Al-4V. PhD Thesis, Coventry University.
- Walker, Michael (2019) Cold Spray Additive Manufacturing of Ni Alloy 718 and High Entropy Alloy CoCrFeMoNi, PhD Thesis, University of Leicester.

Selection of Publications

Sudigdo, P., Bhattiprolu, V.S., Hussain, T. “Cold Spray of Ni-Based Superalloys: A Review on Processing and Residual Stress”. Journal of Thermal Spray Technology 2025.

Sharma, D., Boruah, D., Ameen, A. et al. “Optimizing Cold Spray Parameters for High Entropy Alloy Coatings Using Taguchi and Box–Behnken Design Approaches for Mechanically Alloyed Powder.” Journal of Thermal Spray Technology 2024, 33, 2278–2297.

Sharma, D., Boruah, D., Bakir, A.A., Ameen, A., Paul, S. "Machine Learning-Based Predictions of Porosity during Cold Spray Deposition of High Entropy Alloy Coatings." Coatings 2024, 14, 404.

Boruah, D., McNutt, P., Sharma, D., Begg, H., Zhang, X. "Understanding the Effect of Substrate Preheating Temperature and Track Spacing on Laser-Assisted Cold Spraying of Ti6Al4V." Metals 2023, 13, 1640.

Boruah, D., Zhang, X., McNutt, P., Khan, R., Begg, H. "Effect of Post-Deposition Thermal Treatments on Tensile Properties of Cold Sprayed Ti6Al4V." Metals 2022, 12, 1908.

Boruah, D., Zhang, X. "Effect of Post-Deposition Solution Treatment and Ageing on Improving Interfacial Adhesion Strength of Cold Sprayed Ti6Al4V Coatings." Metals 2021, 11, 2038.

Boruah, D., Robinson, B., London, T., Wu, H., de Villiers-Lovelock, H., McNutt, P., Doré, M., Zhang, X. "Experimental Evaluation of Interfacial Adhesion Strength of Cold Sprayed Ti-6Al-4V Thick Coatings Using an Adhesive-Free Test Method." Surface & Coatings Technology 2020, 381, 125130.

Sabard, A., McNutt, P., Begg, H., & Hussain, T. "Cold Spray Deposition of Solution Heat Treated, Artificially Aged and Naturally Aged Al 7075 Powder." Surface & Coatings Technology 2020, 385, Article 125367.

Boruah, D., Ahmad, B., Lee, T.L., Kabra, S., Syed, A.K., McNutt, P., Doré, M., Zhang, X. "Evaluation of Residual Stresses Induced by Cold Spraying of Ti-6Al-4V on Ti-6Al-4V Substrates." Surface & Coatings Technology 2019, 374, 591–602.

Boruah, D., Zhang, X., Doré, M. "Theoretical Prediction of Residual Stresses Induced by Cold Spray with Experimental Validation." Multidisciplinary Modeling in Materials and Structures 2019, 15, 599–616.

Sabard, A., de Villiers Lovelock, H.L., & Hussain, T. "Microstructural Evolution in Solution Heat Treatment of Gas-Atomized Al Alloy (7075) Powder for Cold Spray." Journal of Thermal Spray Technology 2018, 27, 145–158.

Walker, M. "Microstructure and Bonding Mechanisms in Cold Spray Coatings." Materials Science and Technology 2018, 34(17), 2057–2077.

Peat, T., Galloway, A., Toumpis, A., McNutt, P., Iqbal, N. "The Erosion Performance of Cold Spray Deposited Metal Matrix Composite Coatings with Subsequent Friction Stir Processing." Applied Surface Science 2017, 396, 1635–1648.

Peat, T., Galloway, A., Toumpis, A., McNutt, P., Iqbal, N. "The Erosion Performance of Particle Reinforced Metal Matrix Composite Coatings Produced by Co-Deposition Cold Gas Dynamic Spraying." Applied Surface Science 2017, 396, 1623–1634.

Hussain, T., McCartney, D.G., Shipway, P.H., Marrocco, T. "Corrosion Behaviour of Cold Sprayed Titanium Coatings and Free Standing Deposits." Journal of Thermal Spray Technology 2011, 20(1-2), 260–274.

Marrocco, T., Hussain, T., McCartney, D.G., Shipway, P.H. "Corrosion Performance of Laser Post-Treated Cold Sprayed Titanium Coatings." Journal of Thermal Spray Technology 2011, 20(4), 909.

Further Information

To keep up-to-date with our latest developments, please follow our LinkedIn page: **TWI Cold Spray Technology Centre**.
For any enquiries, please email contactus@twi.co.uk.

Dibakor Boruah
Senior Engineer

d.boruah@twi.co.uk

Phil McNutt
Principal Engineer

phil.mcnutt@twi.co.uk

Ben Robinson
Team Manager

ben.robinson@twi.co.uk

TWI
Granta Park, Abington, Cambridge CB21 6AL