

# FLASH

Flexible Laser-Based Manufacturing

## FLASH: PIONEERING FLEXIBLE LASER-BASED MANUFACTURING ACROSS EUROPE

The European Union-funded FLASH project, officially titled “Flexible Laser-based manufacturing through precision photon distribution,” has reached an important moment in its ambitious journey to transform the landscape of industrial manufacturing. Crossing the halfway point in its three-year mission, the international FLASH consortium now celebrates significant advances that are reshaping how cutting-edge sectors, including medical devices, mobility, and advanced tooling, embracing flexible, sustainable, high-precision manufacturing.

### **Unleashing a New Era of Laser Manufacturing**

Launched in January 2024 under the Horizon Europe programme (Grant Agreement 101138380), and led by an elite alliance spanning Europe’s foremost industrial, research, and technology organisations, the FLASH initiative is creating an unprecedented flexible laser manufacturing platform. At its core is the belief that next-generation industries will require not only the most advanced material processing tools, but also an architecture fundamentally adaptable to fast-evolving products, materials, and sustainability imperatives.

In the first 18 months, the consortium has achieved a series of interlocking technological, organisational, and environmental milestones. These advances pave the way for highly competitive European manufacturing, advancing both productivity and climate neutrality in line with EU strategic goals.

### **Transformative Technology: The FLASH Flexible Laser Platform**

At the core of the project’s achievements stands the development and initial validation of the FLASH flexible laser manufacturing platform. This machine represents a leap beyond traditional laser equipment. It has been designed from the ground up as a reconfigurable, high-precision modular system able to automate tool changing and support three distinct advanced lasers. These lasers, with varying wavelengths, pulse durations, and power levels, are the product of coordinated innovation from across the consortium.



The three integrated lasers—a continuous-wave near-infrared (NIR) fiber laser, a green nanosecond (ns) pulsed fiber laser, and a green long-duration nanosecond diode-pumped laser, each contribute with unique process capabilities. Through a sophisticated “all-in-one” fiber coupling and switch box, these beams can be rapidly directed to three interchangeable beam delivery heads: a nozzle head for high-power thermal processing, a WJGL head for ultra-precise cutting and drilling of advanced ceramics and composites, and a galvos scanner head for micro-machining and surface engineering. The automated head-changeover system, meeting its design target of sub-15-second transitions, guarantees minimal downtime and maximum flexibility—even for highly diversified or small-batch production runs.

## **Breakthroughs in Beam Shaping and Intelligent Control**

A defining innovation of FLASH is its dynamic beam shaping and real-time focus control. By integrating adaptive optics, driven by deformable mirrors, rapid-response actuators, and Cailabs’ proprietary beam-modulation suite, the platform delivers precise photon distribution to match each unique manufacturing task. Within milliseconds, manufacturers can switch from a classic Gaussian beam (suitable for deep penetration welding) to a more tailored top-hat, ring, or composite beam profile, optimised for cleaning, micro-polishing, or edge hardening.

The Z-axis focus shifting module, developed by partners from ROBUST AO GmbH and Cailabs, allows the focal point of the laser to move along a 20-millimeter path in less than 2 milliseconds. This capability ensures optimal processing not only for differently shaped workpieces but also for thick or multi-layered materials, which is crucial for advanced assemblies in electromobility and medical implants.

These shaping modules are not mere add-ons but are seamlessly integrated into the FLASH control system. This architecture empowers a new level of process adaptability. Manufacturers can instantly tailor the energy deposition to material properties, geometry, or even in-situ process feedback, radically reducing defects, energy wastage, and processing time.

In automotive manufacturing, TOFAS is tackling the challenges of joining dissimilar metals, such as aluminum and steel, to create lighter, stronger cross-car beams for electric vehicles. FLASH provides powerful continuous-wave and pulsed lasers, along with advanced cleaning and welding routines, to minimize the formation of brittle intermetallics and ensure durable, high-speed joints capable of meeting the toughest safety standards.

Meanwhile, in the e-mobility sector, ATOP is reaping the benefits of non-contact, residue-free copper hairpin processing. By combining beam-shaped stripping with optimised dual-beam welding, the FLASH solution is enabling faster, cleaner, and more reliable connections for next-generation electric motors.

Toolmakers such as Diamoutils and end-users producing cubic boron nitride (CBN) grinding wheels are also benefiting from FLASH's multistep processing capabilities. In both cases, the project enables dramatically reduced material wastage, elimination of hazardous chemicals otherwise used in electroplating, and extension of tool lifetimes, delivering both economic and substantial environmental gains.

## **AI and Digitalisation Driving Competitive Edge**

A pillar of FLASH's impact is its commitment to digital innovation. The platform directly integrates cloud-connected monitoring, AI-enabled process optimisation, and real-time analytics.

Sensors embedded throughout the machinery feed precise, high-frequency data, from acoustic signals and optical emissions to temperature, energy draw, and geometric tolerances, into centralised, cloud-based models. Early deployment of machine learning algorithms, developed in partnership between ATS and Cosmos Thrace, has yielded promising predictive accuracy. These models analyse hundreds of process parameters to recommend optimal laser recipes and proactively detect signs of process drift well before costly defects occur.

Furthermore, FLASH is developing and embedding advanced lifecycle assessment (LCA) tools into its digital workflow. This approach ensures that manufacturing sustainability is addressed not only reactively but also in real time, with impact metrics directly influencing process choices and driving continuous improvement toward green manufacturing.

## **Building European Skills and Standards for the Future**

Recognising that technology adoption depends on people and systems as much as machines, the FLASH project has invested heavily in training, capacity building, and standardisation. Four internal lectures already been delivered, covering not only laser processing but also sustainability frameworks, digital infrastructure, and in-process monitoring.

In parallel, FLASH is taking a leadership role in shaping the standards that will govern advanced manufacturing for years to come. By mapping over 10 complementary R&D projects and forging collaborations with key EU clusters (such as EFFRA and Made in Europe), FLASH is ensuring that its innovations have both immediate and lasting impact across the continent.

## Sustainability and Circularity Embedded by Design

The FLASH consortium recognises that the success of new manufacturing technologies will increasingly be defined by their environmental footprint. Every aspect of the project, from process design and machine architecture to business modelling and training, incorporates circularity, resource efficiency, and climate action as fundamental design criteria.

By developing detailed LCA and cost-benefit analysis models, FLASH empowers manufacturers to compare conventional and laser-based scenarios on a full lifecycle basis. For example, the replacement of multi-station, high-scrap manufacturing lines with the modular FLASH platform has already revealed significant savings in energy, material use, and hazardous chemicals.

These tools, coupled with experimentation and AI-driven optimisation, are delivering measurable benefits such as up to 50% reductions in cycle time for medical implants, elimination of polluting chemicals in toolmaking, and substantial scrap and energy savings in mobility applications.

## Laying the Groundwork for Commercial Impact

Europe races to secure its leadership in advanced manufacturing amid disruptive global competition, the FLASH project is already preparing for commercial exploitation. Preliminary licensing agreements have been drafted for both the machine platform and key process technologies, defining intellectual property rights, royalty frameworks, and support services.

Business models are being developed with end-users across the medical, tooling, automotive, and e-mobility sectors, laying the groundwork for rapid post-project commercialization and widespread technology adoption.

## Looking Ahead: Roadmap to Full Integration and Demonstration

With all major technological building blocks now validated, the FLASH project is entering a critical integration and demonstration phase. The next milestones focus on the full-scale assembly of the machine demonstrator, the integration of all laser, optics, control, and AI modules, and the expansion of live trials with participating industrial partners.

Through these efforts, FLASH will not only bring flexible, digitalized, and sustainable manufacturing solutions closer to industrial reality but will also help shape the European debate on the future of advanced manufacturing.



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