



FAST

Functionally graded
Additive Manufacturing scaffolds
by hybrid manufacturing

EXPLOITATION

Introduction

This documents lists all companies with their products that were used or designed in this project. It further gives clues to their intended economic use.

Tools for Bioprinting

NADIR s.r.l. Plasma & Polymers (I)



www.nadir-tech.it



Products

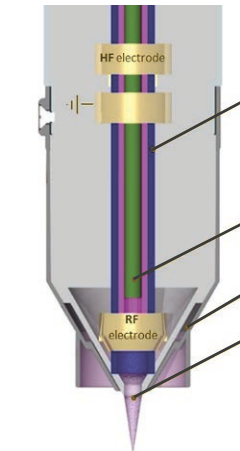
Nadir Plasma Jet Module

Description

The Nadir Plasma Module is an atmospheric plasma jet that allows the ionization of argon gas by applying high voltage (HV) near the channel where the gas is flowing. A cold (40 °C) and efficient plasma is sustained with a second coupled power supply operating at radio frequency (RF), ensuring high density of active species (free ions, radicals and electrons) at room temperature.

Technical specs

- Double dielectric barrier discharge design: ensures clean surface treatment of all materials, avoiding any electrode erosion and the related contamination with metallic particles
- Working gas: argon at 5–10 standard litres per minute (slm), through a dedicated plasma channel
- Carrier gases to introduce chemical precursors as vapours or aerosols: argon, nitrogen, air (0.2–5 slm), through a dedicated capillary.
- Reactive gases: Ar/O₂, Ar/H₂ mixtures or CF₄, through a dedicated capillary.
- Cooling or shielding gas: N₂ or air, through a dedicated external channel
- Spot size: 1 cm²
- Surface activation rate: 1–10 cm²/s
- Deposition rate: 10 nm · cm²/s



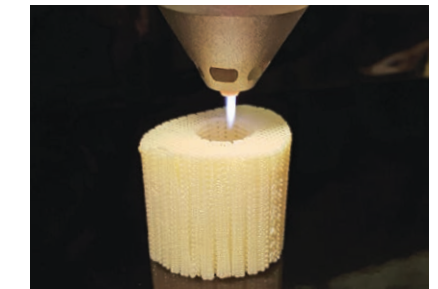
Schematic of the Nadir Plasma Jet Module: argon channel (1), carrier gas or reactive gas capillary (2), cooling or shielding gas channel (3), plasma plume (4)

- Pulsing system
- IoT communication with BioScaffolder, plotters or remote terminals
- CE legislation approved
- Dual frequency (HF + RF) plasma generation system
- Patented design

Applications

Integration of the Nadir Plasma Jet Module into the GeSiM BioScaffolder hybrid bioprinter for:

- Activating and cleaning the whole object porosity (example: plasma activation of a bone 3D scaffold)
- **Sterilization** with oxidative plasma during polymer printing
- Functionalization with a proper chemical precursor without solvents
- Graded properties in biochemistry, such as cell growth or antibiotic activity
- Reductive or oxidative plasma can be used to **clean** surfaces, remove organic dirt or polymeric layers



Plasma treatment of a bone biopolymer scaffold during printing

- Surfaces can be activated to **improve adhesion** of cells, printed material or different melted materials
- Inlet capillary for the introduction of vapour and aerosol precursors allows **deposition** of functionalities, coatings and nanocomposites

Commercial impact

The Nadir Plasma Jet Module is already available on the market. It can be coupled with the GeSiM BioScaffolder, mounted on different GeSiM platforms or used as an independent tool.

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7



Nadir plasma jet mounted on a GeSiM BioScaffolder BS5.1. The high-temperature gradient mixer is in the back.

Materials for Bioprinting

GeSiM mbH (D)

GESIM

www.gesim.de



Products

BioScaffolder BS3.2, BS5.1

Description

Universal PLC-controlled 3D bioprinter, in combination with micro-liquid handling and various other tools

Technical specs

- Belt- or linear-motor-driven, different sizes, usually works in biosafety cabinet
- Various tools on the work plate, e.g. tip measurement, tip cleaning and wash/dry station for liquid microdispensers, heated/non-heated microtitre plates, heat plate
- Various tools on the tool head: heatable/cooled cartridge holders (5–190 °C), piezo and solenoid valve dispensers, high-temp. piston extruder (HTEt, RT–250 °C), unheated piston extruders, FDM extruder, UV curing etc.
- Easy to use GUI with consistent user interface, reliable CAD import, programme sequences etc.

Achieved goals in the FAST EU project

- Integration of NADIR's plasma pen into the GeSiM BioScaffolder systems (see picture on previous page)



Toothbelt-driven BS3.2 with high-temperature piston extruder (left) and prepared for piezo dispenser



BS5.1 with linear motors, equipped with high-temperature gradient mixer (left) and non-heatable piston extruder

- Construction of the BS5.1 to carry a twin HTEt
- Development and test of an ISG-type static gradient mixer for polymers consisting of two HTEts and a heatable static mixer

Commercial impact of the developed tools

All tools developed in this project are already being marketed and sold, also a coolable gradient mixer.

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7



Gradient mixer in a BS5.1 dispensing concentric gradients of 0...20% zirconium phosphate + gentamicin antibiotic in PEOT/PBT

Polyvation BV (NL)

PolyVation
INITIATE • INNOVATE • CREATE

www.polyvation.com



Products

PEOT/PBT multi-block copolymer

- Research and medical grade

PEOT/PBT polymer composites (master batches)

- Hydroxyapatite (HA) filled research specialties
- Layered double hydroxide (LDH) filled research specialties
- Zirconium phosphate (ZrP) filled research specialties

Description

- Biocompatible, elastomeric, bioresorbable
- Cell and tissue friendly

- Allows printing, extrusion, injection moulding
- Available in multiples of 100 to up to 1,000 grammes

Applications

- Tissue engineering implants
- Bone regeneration implants

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7



PolyVation PEOT/PBT powder

Prolabin & Tefarm s.r.l. (I)

Prolabin&Tefarm
Polymer Additives, Cosmetic Ingredients, Catalysts

www.prolabintefarm.com



Fillers as drug delivery systems for bioactive molecules

Products

LDH Layered double hydroxides (hydrotalcite) intercalated with anionic or acidic biomolecules (e.g. ciprofloxacin antibiotic)

- Biocompatible materials in MgAl or ZnAl forms

ZrP Zirconium phosphate (alpha type) intercalated with cationic or basic biomolecules (e.g. gentamicin antibiotic)

- Biocompatible material and high thermal stability

Masterbatches with different polymers and biopolymers

- Layered double hydroxide (LDH) filled research specialties
- Zirconium phosphate (ZrP) filled research specialties

Description

- Inorganic-organic fillers
- Drug delivery systems
- Allows printing, extrusion, injection moulding, electrospinning
- Available quantity for R&D: up to 1,000 g, in multiples of 10
- Available bulk quantities: up to 1,000 kg, in multiples of 5

Applications

- Drug delivery systems
- Tissue engineering implants
- Wound healing
- Biopolymeric composites
- Active polymeric composites

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7

Nadir s.r.l. Plasma & Polymers (I)



www.nadir-tech.it



Products

Polymer compounds with active and bioactive properties

Description

Nadir is a supplier of custom polymer compounds for users interested in innovative polymers or in blending a polymer with performance additives or other polymers to achieve specific properties for special applications.

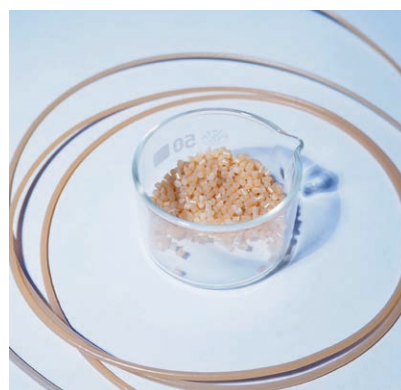
Nadir formulations are obtained by melt compounding technology than can incorporate in a specific thermoplastic a wide range of innovative fillers with various loadings, by maintaining the original processability of the neat polymer.

Applications

- Polymer compounds with biological activity: antibiotics, antimicrobial or antifungal agents, bone minerals, and compounds affecting cell differentiation
- Polymer compounds with advanced properties: electroconductive, thermally conductive, radiopaque, metal detectable, etc.

Available products

- PEOT/PBT filled with ZrP lamellar fillers incorporating gentamicin antibiotic (5, 10 or 20 wt%)
- PEOT/PBT filled with LDH lamellar fillers incorporating ciprofloxacin antibiotic (5, 10 or 20 wt%)
- PEOT/PBT filled with reduced graphene oxide (rGO) (3/10/15 wt%)
- PMMA with radiopaque properties
- TPU (thermoplastic polyurethane) with electroconductive properties (tunable resistivity from 2 Ω cm to 2 M Ω cm)
- PCL (polycaprolactone) filled with hydroxyapatite (up to 20 wt%)
- PETG filled with silver nanoparticles (up to 5 wt%)

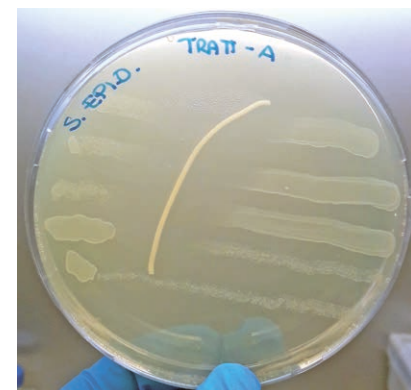


Filaments for 3D printing

All products are also available as filament wires for FDM 3D printing technologies with calibrated diameter (1.75 or 2.85 mm)

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7



Example of a polymer filament with antibacterial activity, on a Petri dish



Top, PEOT/PBT filled with LDH (layered double hydroxide) lamellar fillers incorporating ciprofloxacin antibiotic. Bottom, PEOT/PBT filled with reduced graphene oxide.



Radiopaque PMMA (top) and a ready-to-use Nadir spool wire (bottom)

Abalonyx AS (N)

Dosable Reduced Graphene Oxide



www.abalonyx.no



Products

Dosable reduced graphene oxide

- Pre-commercial grade
- Six products in product family

Description

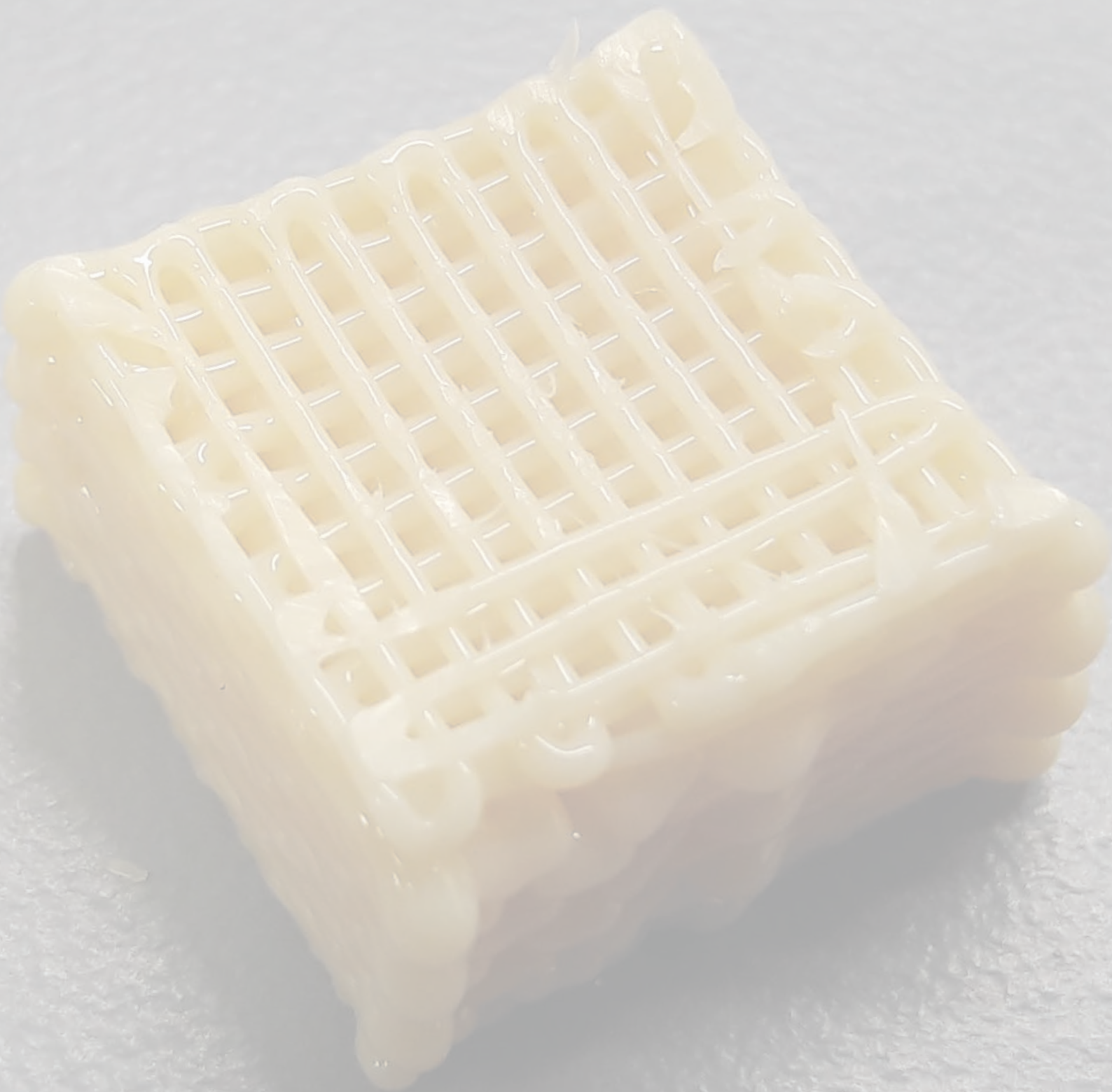
- Dosable with automated powder dosers
- High surface area
- Can be supplied as partly (C/O = 7), medium (C/O=20) or fully reduced (C/O = 100)
- Can be supplied as acidic and de-acidified grade
- Availability from 2 g to multiple kilogrammes

Application

- Polymer composites
- Conductive inks
- Catalyst support

Funding source

FAST, Project no. 685825; Horizon 2020, Framework 7



project-fast.eu



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