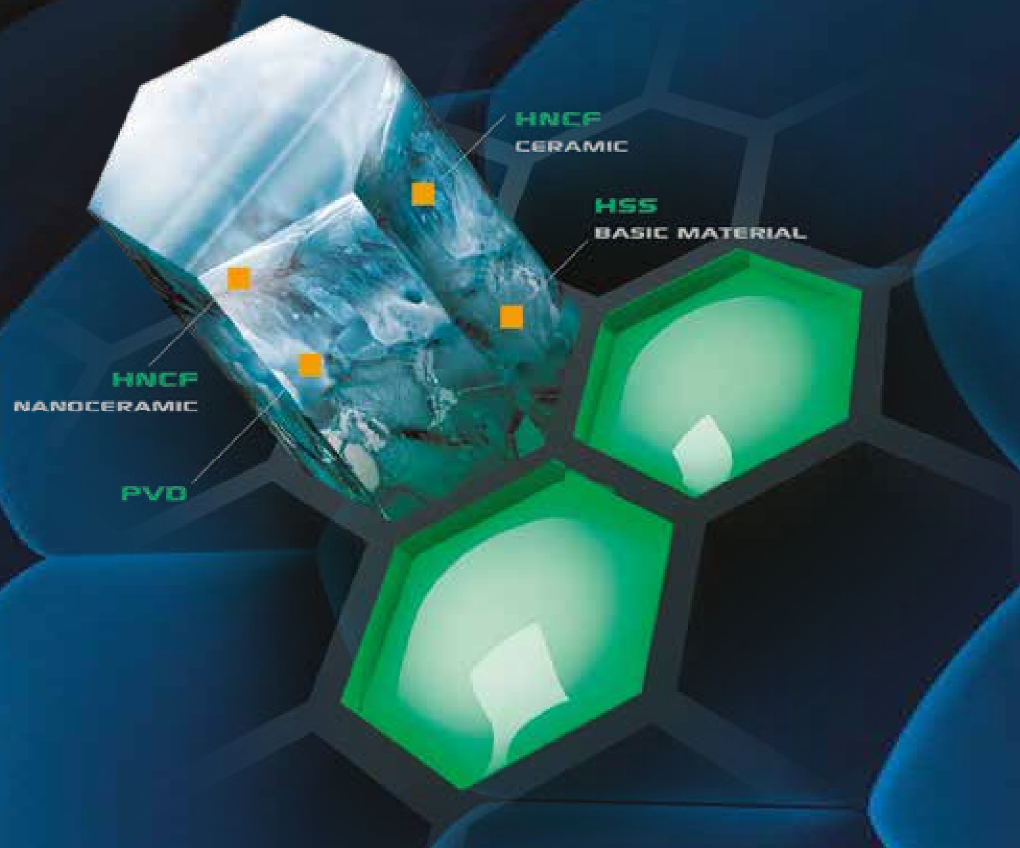
ADVANCED SURFACE TECHNOLOGIES

CERAMIC AND NANOCERAMIC COATINGS

FOR OIL & GAS AND CRYOGENIC APPLICATIONS



Our History

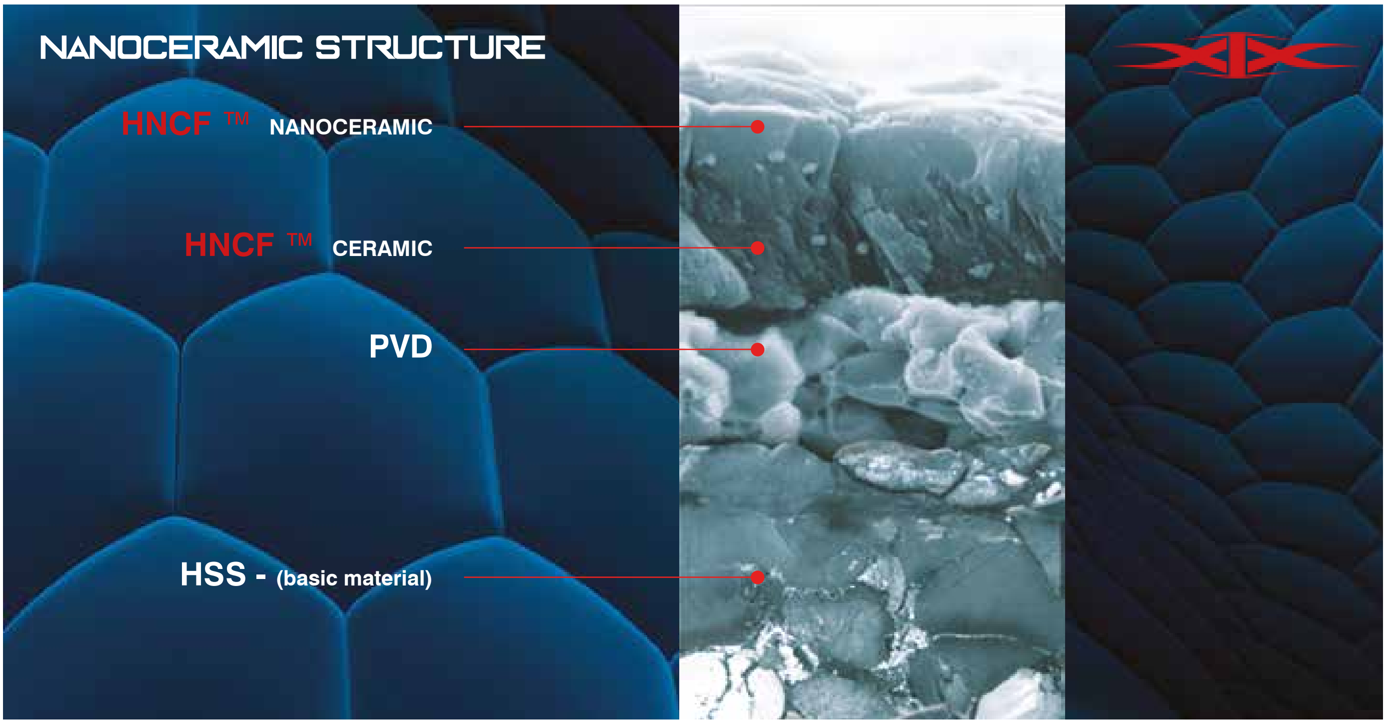
Since the 1990s, X1X has been developing structural and surface coatings based on ceramic and nanoceramic technology, primarily for the oil & gas sector, through its proprietary patented process **HNCF™ (Hard Nano Ceramic Finishing™)**.
Engineered surface technologies that create ultra-resistant multilayer functional coatings by bombarding the components to be treated with ceramic and nanoceramic particles.
The HNCF™ process can be fully customised according to the application sector and customer requirements in order to achieve maximum performance and resolve the majority of problems.

What is Nanoceramic Coating?

HNCF™ nano-layers are miniaturised in a sterile, amorphous environment and deposited onto any metal or non-metal substrate, creating an ultra-thin protective layer ranging from 1 to 10 μm. that becomes an integral part of the surface. The result delivers exceptional mechanical resistance, high surface hardness, excellent thermal stability and friction reduction, acting as a "*dry lubricant*" at extreme operating temperatures. The surface hardness provided by the nano-layer can reach up to 7÷9 times greater than conventional hard chrome or electroless nickel plating, and 3÷6 times greater than HVOF coatings. The friction coefficient reduction can reach up to -90% compared to metal-to-metal contact, protecting substrates against abrasion, corrosion and cavitation induced by flowing fluids.

HNCF ™ VS TRADITIONAL COATING TECHNOLOGIES

The image below clearly shows how the molecular structure of HNCF™ technologies (ceramic and nanoceramic) compares with traditional coating technologies considered advanced today, including PVD (Physical Vapor Deposition) metallic deposits and High Speed Steel structures (HSS) sintered with hot powder technology (HIP). The structural superiority of HNCF™ layers is evident above all at the molecular level, offering exceptional performance that conventional technologies cannot match. When compared with the main deposition technologies available on the market Electroless Nickel, PVD, DLC, HVOF, Stellite, etc. in the Oil & Gas and LNG sectors, ceramic/nanoceramic systems outperform them on all fronts. Among the components that benefit most are balls, seats, stems and sleeves.



Technology	Hardness (HV)	Thickness	Friction Reduction	Corrosion Resistance
HNCF ™ Nanoceramic	4400 - 5750	1 - 9 µm	Up to - 90%	Excellent
HNCF ™ Ceramic	2000 - 3500	1 - 9 µm	Up to - 70%	Very Good
PVD	1500 - 3000	2 - 5 µm	Moderate	Good
Hard Chrome	800 - 1000	10 - 300 µm	Low	Moderate
HVOF	1050 - 1400	100 - 400 µm	Low	Moderate

HNCF ™ APPLICATION PROCESS

Phase 1 - Ionic Plasma Nitriding (NIP) - Optional

Surface-hardens the substrate creating a mechanical backing. Applied to soft materials (stainless steels), rarely used with Nickel alloys or Duplex steels.

- *Without backing, PVD/DLC deposits risk spalling under point loads.*

Phase 2 - Ultra-High Velocity Bombardment (416 km/s)

Particles bond at molecular level into the crystal lattice - no delamination possible.

- *Unlike PVD/DLC mechanical bonding, HNCF ™ creates a single metal ceramic entity.*

Phase 3 - HNCF ™ Ceramic or Nanoceramic Finish (1.5 - 10 μm)

Ultra-resistant barrier against abrasion, impact and corrosion, with resilient elasticity.

- *Unlike brittle HVOF/Electroless Nickel, HNCF ™ absorbs impact like a resilient armour.*

01 **Surface Preparation**

Precision cleaning and surface activation to ensure optimal nanoparticle adhesion.

02 **Vacuum & Degassing**

The component is placed inside a dedicated chamber where vacuum is applied and the piece is fully degassed.

03 **Nanoparticle Bombardment**

Ceramic nanoparticles are projected onto the rotating component. The piece rotates on three axes to ensure a perfectly uniform coating distribution.

04 **Multi-layer Deposition**

Multiple layers are applied in sequence until the required final thickness (1,5 - 10 μm) is achieved. Process repeatability is ensured by dedicated software that manages the entire coating cycle.

05 **Removal, Inspection & Certification**

The coated component is removed from the chamber, subjected to full dimensional inspection and certified to customer specifications.

HNCF ™ Coating Equipment

Coating Process Control Panel

Quality Control Laboratory

Performance Results & Economic Benefits

- **Hardness —** 3.500÷6.000HV (approaching diamond hardness). Outperforms TCC-HVOF and Stellite, withstands violent impacts and solid debris.
- **Friction —** Reduction of up to -90%. No traditional technology (PVD, DLC, Nickel, Stellite) delivers the same result.
- **Corrosion —** Chemically inert, does not react with strong acids and does not trigger galvanic corrosion. TCC-HVOF and Stellite are vulnerable to H_2S and chlorides.
- **MTBF —** Operational life tripled compared to TCC-HVOF or Stellite.
- **Actuators —** Torque reduced by up to 80% direct cost saving on actuators and support structures.
- **Maintenance —** Near zero, ideal fot HP/HT wells, subsea installations and refining.

Specific Oil & Gas Applications

Over the years X1X has developed more than 380 deposits and treatments for a wide range of service conditions. For the Oil & Gas sector, two coating grades are primarily used. Their main characteristics are described below.

H38
CERAMIC COATING

Multilayer ceramic coating with hardness varying between 2.800÷3.100 HV and a friction coefficient of around 0,18. It performs well at high temperatures (850°÷925°C.) but also at low temperatures if desired. It resists a good range of corrosive acids - a good compromise between sufficiently high performance and an affordable price.

Color	Titanium Grey
Hardness	2.800÷3.100 HV
Melting Point	1.305°C
Max. Work Temp.	875°C
Friction Coefficient	0,18
Structure	Hexagonal

BLUE
NANOCERAMIC COATING

Multilayer nanoceramic coating with exceptional hardness characteristics and a very low friction coefficient. Hardness varies between 5.250÷5.750 HV depending on the version applied, with a friction coefficient of around 0,07÷0,10. Resistance to high temperatures is exceptional, ranging between 1.150°÷1.200°C. Resistant to various corrosive agents, it features very high elastic characteristics despite the very high surface hardness. Its hexagon-shaped nanometric molecular structure ensure that particles always share one or more sides with neighbouring nanoceramic particles. This makes the deposit highly resistant to fracture and flaking, as its modulus of elasticity (Young's modulus) is generally higher than that of the substrate - meaning the base material must yield before the coating.

Color	Dark Blue
Hardness	5.250÷5.750 HV
Melting Point	n.a.
Max. Work Temp.	1.250°C
Friction Coefficient	0,07÷0,10
Structure	Hexagonal

COATING COMPARISON - OIL & GAS APPLICATIONS

HNCF™ ceramic and nanoceramic coatings vs. common Oil & Gas surface treatments

Surface Treatment/Coating	Process	Coating Composition	Thickness	Hardness	Friction Factor	Service Temp.
Ionic Plasma Nitriding	Thermochemical	N/A	0.10 - 0.50 mm	1000 - 1200 Hv	0.25	450°C
Electroless Nickel Plating	Chemical	Nickel + Phosphorus	0.025 - 0.075 mm	500 - 1000 Hv	0.25	300°C
Ceramic Coating (H38)	Atomization ceramic particles	Cr2O3 + Si3N4	1 - 9 μm	3100 - 4500 Hv	0.18	-175°C÷875°C
Chromium Carbide Coating	HVOF	75% Cr3C2 + 25% NiCr	0.15 - 0.40 mm	800 - 1000 Hv	0.15	550°C
Nanoceramic Coating (BLUE)	Atomization nanoceramic particles	Al203 + Y2O3 Whisker	1 - 9 μm	5100 - 6750 Hv	0.05 - 0.07	-237°C÷1.250°C
Spray & Fuse Coating	HVOF + remelting in oven	Cr19-Ni18-W10-B3.4-Si2.8-Co	0.15 - 0.60 mm	750 Hv	0.20	850°C
Tungsten Carbide Coating	HVOF	86% WC + 10% Co + 4% Cr	0.10 - 0.40 mm	1050 - 1200 Hv	0.12	220°C
Tungsten Carbide Coating	HVOF	N/88% WC + 12% Co	0.10 - 0.40 mm	1050 - 1400 Hv	0.10	220°C

HNCF™ Ceramic Coating (H38) and Nanoceramic Coating (BLUE)

Unmatched Technology

Both configurations NIP + Ceramic or Nanoceramic (recommended for soft substrates such as Stainless Steels) or Ceramic/Nanoceramic only (sufficient for harder materials such as Nickel alloys, Duplex and precipitation-hardening steels) are technologically defined as **UNMATCHED**. Market analysis confirms that no civil manufacturer currently offers these characteristics as standard. Compared to traditional technologies (TCC-HVOF, Stellite, PVD, DLC, Electroless Nickel), ceramic and nanoceramic deposits offer superior hardness, zero delamination, minimal friction, total chemical resistance and significantly longer operational life the reference standard for strategic projects in both Oil & Gas and LNG.

HNCF™ Coatings for Cryogenic Applications

The BLUE nanoceramic coatings is widely used for Low-Temperature applications, including liquid Hydrogen(H) environments. Nanoceramic deposits applied to valve seats, stems, bearings and other components have radically changed the approach to Cryogenic Engineering. Valve components made from Inconel, Hastelloy, Superalloys or Stainless Steel coated with BLUE have for years been in common use for liquid Nitrogen environments at -190°C. In recent years, the same components are also used with cryogenic fluids at -237°C such as Hydrogen(H), with highly satisfactory results.

Certifications & Intellectual Property

X1X operates under a certified Quality Management System certified in compliance with **ISO 9001:2015**, issued by CISQ/ICIM S.p.A. and recognised by IQNET, covering the scope of special coatings based on metal, ceramic, nanoceramic and diamond. X1X holds licences, registered trademarks and patents relating to the HNCF™ process for the application of ceramic and nanoceramic coatings, registered both in the United States and in Italy.


ICIM
X1X S.R.L.
UNI EN ISO 9001:2015

ISO 9001:2015 - IQNET/CISQ


United States of America


ATTESTATO DI REGISTRAZIONE PER MARCHIO DI IMPRESA

HNCF™ Trademark – USA & ITALY

ADVANCED SURFACE TECHNOLOGIES

X1X SRL
St. Serenissima 7 - 25135 Brescia (ITALY)
Tel. ++39 / 030 / 30.09.09 – 31.77.99
Fax ++39 / 030 / 30.38.30
info@oilgasx1x.com
info@x1xtech.com

ICIM
UNI EN ISO 9001:2015
SISTEMA DI GESTIONE CERTIFICATO