A New Class of Functional Materials for Extreme Environments

Scientific and Technical Overview of Developments by Asia Quartz LLP

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This document is intended for the scientific community and potential partners for joint research and commercialization.

ABSTRACT

Asia Quartz LLP (Kazakhstan) presents the results of years of research and development in the field of advanced materials exhibiting anomalous physicochemical resistance and unprecedented structural stability. Based on a proprietary phase selection technology, a platform of eight unique materials has been created — ALEM, ALEM+, ADIL, ANEL, ALAN M+, D16-ALEM, and ARKTIKA — each designed to address critical challenges in the aerospace, energy, microelectronics, and defense industries. In parallel, an innovative technology has been developed for extracting osmium and platinum group metals (PGMs) from copper ores via selective induced metallization, bypassing the formation of toxic osmium tetroxide (OsO_4).

Keywords: ALEM, ADIL, ANEL, ALAN M+, ARKTIKA, SiO_2, carbon nanomaterial, acicular quartz, osmium, platinum group metals, heat-resistant materials, microelectronics, quantum computing, phase selection.

1. INTRODUCTION: CONTEXT AND CHALLENGES

1.1 Fundamental Limitations of Modern Materials

The development of key Deep Tech sectors — from hypersonic aviation and thermonuclear energy to quantum processors — is constrained by a structural gap in materials science. Industry faces the so-called “thermal wall” at the 2,000–3,000 °C threshold: a fundamental temperature limit for the best existing materials, including tungsten- and tantalum-based superalloys and state-of-the-art technical ceramics.

In parallel, a dual crisis exists in the high-tech raw materials sector:

- Synthetic quartz deficit: microelectronics and optics critically depend on expensive synthetic quartz, whose production is limited and non-scalable.
- Unsuitability of natural feedstock: conventional quartz sand lacks the purity and morphology required for high-tech applications.

1.2 Positioning of Asia Quartz

Asia Quartz is a research laboratory that has developed a technology platform which does not improve existing materials but creates materials with previously unattainable properties based on new principles of structural self-organization of matter. Askar Rakhimberdinov’s proprietary methodology of structural reorientation of silicon dioxide shifts the fundamental temperature barrier from ~3,000 °C to 14,000 °C (for the StAlem alloy under plasma exposure).

2. BASE TECHNOLOGY: CONTROLLED DESTRUCTURIZATION AND RECRYSTALLIZATION

2.1 Scientific Hypothesis: The "Primordial State" of Matter

The technological platform is founded on the hypothesis of a special phase state — an "archetypal" or "primordial" state — in which the crystal lattice is free of defects characteristic of ore-derived metals and possesses an altered electronic configuration. The ALEM purification technology does not create material from scratch but removes external mineral deposits, "liberating" the primordial crystal lattice, which:

- is free of induced dislocations;
- possesses quantum and electronic stabilization;
- contains a metastable hybrid lattice with controlled phonon transport.

2.2 Controlled Destructurization Method

1. Destructurization — controlled breaking of interatomic bonds and relief of internal stresses while preserving the chemical composition. Achieved through a combination of thermal exposure, microwave excitation, mechanical stress, and ionic activation.
2. Directed recrystallization — formation of a pseudo-ideal crystal structure without a single nucleation center, with simultaneous formation of multiple coherent regions at minimal thermal gradients.
3. Result: formation of a quasi-crystalline structure with minimal defect density, absence of domain boundaries, anomalously low thermal conductivity, and record-breaking heat resistance.

2.3 Feedstock Base

- Metallurgical slag from non-ferrous smelting (Ust-Kamenogorsk metallurgical complex);
- Barchan sands from UAE deserts (Rub al-Khali);
- Copper ores and concentrates for PGM extraction.

3. MATERIALS FAMILY: DETAILED CHARACTERIZATION

3.1 ALEM — High-Purity Mesoporous Silicon Dioxide

Ultra-pure heat-resistant ceramic based on silicon dioxide (SiO_2) obtained from metallurgical slag by controlled destructurization and recrystallization.

Parameter	Value
Chemical composition	SiO_2 — 99.9%+
Impurity content	Fe_2O_3 ≤ 0.006%; CaO ≤ 0.004%
Degradation temperature	>3,500 °C
Particle morphology	10–60 μm, uniform
Thermal conductivity	0.02–0.04 W/m·K
Structure	Mesoporous (d_p ~ 37.5 nm)
Phase composition	α-quartz phase (peak 2θ ~ 26.6°)
Crystallinity	High, near ideal

Verification: XRF, XRD, SEM-EDS, IR spectroscopy, BET adsorption.

Unique properties:

- Self-glazing effect under critical heating;
- Heat resistance more than 2× the melting point of ordinary quartz;
- Retains piezoelectric properties with reduced noise floor;
- Phonon transport suppression — reduction of thermal noise.

Applications: processor substrates (Advanced Packaging); thermal protection panels for aerospace; next-generation refractories; quantum resonators; thermonuclear structures.

3.2 ALEM+ — Enhanced Thermal Barrier Substrate

A modified version of ALEM with a closed functional phase for thermal damping. Compatible with tungsten matrices (W-Os-V) for thermonuclear installations. A multilayer first-wall architecture for fusion reactors has been developed (W-Os-V / ALEM+ / ANEL-ALAN M+). Modeling demonstrates:

- Reduction of peak thermal stresses by a factor of 2–3;
- Increase in thermal cycles to failure by a factor of 5–10;
- Reduction in microcrack growth rate by more than 10×.

3.3 ADIL — Natural Acicular Single-Crystal Quartz

The world's first natural acicular morphotype of high-purity SiO_2 extracted from UAE barchan sands using a proprietary method of fractionation, purification, and structural reorientation.

Parameter	Value
Feedstock	Barchan sands, 30 km from Dubai
SiO_2 purity	99.997% (Electronic Grade)
Morphology	Acicular (length 20–150 μm, thickness up to 1 μm)
Aspect ratio	Up to 150:1
Thermal conductivity	0.04 W/m·K

Crystallography	Absence of lattice defects

Scientific novelty: For the first time, an acicular morphotype has been obtained from natural feedstock without artificial synthesis. No industrial analogues have been identified.

Applications: microelectronics, 5G/6G antennas, MEMS sensors, piezoresonators, optical waveguides.

3.4 ANEL — Carbon Functional Nanomaterial

An original carbon nanomaterial with a hexagonal diamond-like lattice (sp^2/sp^3 hybrid).

Parameter	Value
Heat resistance	>3,500 °C (no deformation); >4,000 °C (with conductivity)
Electrical conductivity	Comparable to or exceeding graphene and silver
Chemical resistance	Insoluble in acids; does not oxidize
Min. conductor size	~1 nm

Surpasses graphene in heat resistance and strength.

Applications: quantum computers, microelectronics, supercapacitors, combustion chambers, anti-corrosion screens, fusion reactor first wall.

3.5 ALAN M+ — Multifunctional Supercomposite

A hierarchical hybrid composite of ANEL + ALEM containing no metallic phases. Electrical resistance of 0.0 Ω at extreme temperatures (>3,000 °C). Coherent bonding of dielectric (SiO_2) and conductive (C) phases.

Target applications:

- Extreme electronics: monolithic substrate + active elements + housing system;
- Water-independent AI infrastructure: data centers without water cooling, heat = resource;
- Aerospace: “smart” armor for UAVs and satellites, maneuvering at >Mach 10;
- Thermonuclear energy: energy-active plates in the reactor first-wall structure.

3.6 D16-ALEM — Modified Aviation Alloy

Aviation-grade aluminum alloy D16 modified with ALEM additive via the master-alloy method.

Parameter	D16 (baseline)	D16-ALEM (1–3% ALEM)
Tensile strength	440 MPa	460–500 MPa
Operating temperature	Up to 200 °C	300–350 °C
Wear resistance	Baseline	2–3× increase
Fatigue limit	Baseline	+20–30%
Service life	1×	2–3×

3.7 ARKTIKA — Modified Structural Steel

Structural low-alloy steel 09G2S modified with ALEM additive (0.3% by charge mass) introduced into the liquid melt. The modifier dramatically improves impact toughness without negatively affecting standard strength and ductility properties. Testing conducted at IMET, Ural Branch of RAS (Yekaterinburg, 2026).

Parameter	09G2S (baseline)	ARKTIKA (0.3% ALEM)
KCU at +20 °C, J/cm²	60–70	**308–321 (×4–5)**
KCU at −60 °C, J/cm²	Sharp drop	**157–287**
Yield strength $\sigma_{0.2}$	300–350 MPa	322 MPa
Ultimate tensile strength σB	450–490 MPa	492 MPa
Elongation δ	21–25%	29.8%
Reduction of area ψ	45–55%	56.1%
Hardness HB	120–150	135–150

Scientific novelty: ALEM modifier at microdosing (0.3%) transforms standard structural steel into a super-tough material with a 4–5× increase in impact toughness while fully preserving the balance of strength and ductility. Specimens did not fracture completely during impact testing — a ductile fracture characteristic of super-plastic materials.

Applications: cryogenic equipment (vessels and pipelines at temperatures below −60 °C); critical welded structures for Arctic climates (bridges, cranes, oil & gas facilities of the Far North); power engineering (parts under impact and dynamic loads).

Verification: IMET, Ural Branch of RAS (Yekaterinburg); testing per GOST 9454-78 (impact toughness) and GOST 1497-84 (tensile); IO 5003-0.3 pendulum; Zwick/Roell machine.

4. ADDITIONAL DEVELOPMENT: StAlem — SUPERALLOY

Parameter	Value
Composition (XRF/EDS)	Ti (~42%), Fe (~33%), Zr (~12%), Os (~0.3%)
Chemical inertness	Absolute — to HNO_3, HCl, H_2SO_4, and Aqua Regia
Heat resistance	>10,000 °C (plasma gun — zero ablation)
Hardness	>75 HRC
Packing density	Ultra-dense intermetallic composite

The presence of osmium (0.3%) provides exceptional atomic packing density and blocks standard oxidation-reduction reactions. Metals (Fe, Ti) exhibit properties characteristic of noble platinum group metals.

5. OSMIUM AND PLATINUM GROUP METAL EXTRACTION

5.1 Selective Induced Metallization

A fundamentally new methodology has been developed for extracting osmium from copper ores, based on induced stabilization of dispersed platinum forms into the metallic state Os^0.

- Does not involve the formation of volatile and toxic osmium tetroxide (OsO_4);
- Allows direct production of copper-osmium metallic concentrate;
- Treats copper ores as a potential source of osmium;
- Environmentally safe process.

5.2 Extraction Method

1. Specialized ionic solutions — suppression of oxidative channels leading to OsO_4 formation, ensuring a direct pathway for osmium reduction to the metallic state.
2. Electromagnetic and frequency exposure — polarization of electron clouds, selective release of osmium centers.
3. Quantum-induced aggregation — formation of metallic clusters and stabilization in the crystalline phase.

5.3 Results

- Copper-osmium concentrate obtained with osmium content ranging from ~10% to ~50%;
- Crystalline osmium structure without the intermediate OsO_4 stage;
- Guaranteed supply volume: 10 kg of concentrate (3 × 46% Os) per month;
- Data confirmed by Olympus Vanta portable XRF analyzer.

6. APPLICATION POTENTIAL IN MICROELECTRONICS AND QUANTUM COMPUTING

6.1 Post-Silicon Paradigm

Parameter	Silicon	Si-Ta / In	ALEM Platform
Operating temperature	≤150 °C	≤800 °C	≥2,000 °C
Minimum feature size	3–5 nm	~5 nm	~1 nm (ANEL)
Radiation resistance	Low	Medium	Very high
Metals in active zone	Required	Required	None
Fab dependency	Full	Full	Minimal

Solving the qubit decoherence problem: StAlem minimizes parasitic magnetic and electrical fluctuations. Solving the thermal throttling problem: ALEM with zero thermal expansion eliminates deformation during multi-level chiplet assembly.

7. VERIFICATION AND CURRENT STATUS

Parameter	Value
XRF (Olympus Vanta)	Chemical composition, ALEM purity (99.9%) and ADIL (99.997%)
XRD	α-quartz phase, high crystallinity
SEM-EDS	Particle morphology, absence of heavy metals
IR Spectroscopy	Characteristic Si-O-Si bands
BET Adsorption	Mesoporous structure (d_p ~ 37.5 nm)
Plasma gun (>4,000 °C)	Zero ablation of StAlem
Aqua Regia	Complete chemical inertness of StAlem

Intellectual property: Kazakhstan Patent No. 29640; international PCT application in preparation.

8. COLLABORATION PROPOSAL

8.1 Priority Directions for Joint R&D

- HR-TEM and SAED analysis: atomic lattice mapping of StAlem to confirm the “Primordial Phase” hypothesis;
- 3D-IC prototyping: integration of ALEM into chip packaging processes;
- Quantum testing: assessment of material effects on qubit parameters;
- ANEL verification: independent measurements of electrical conductivity and heat resistance;
- Osmium extraction scale-up: technology optimization and pilot plant construction;
- Thermonuclear applications: testing the W-Os-V / ALEM+ / ANEL architecture.

8.2 What We Offer Partners

- Transfer of samples of all materials for independent stress testing;
- Complete technical documentation and test protocols;
- Joint publication of results in peer-reviewed journals;
- Technology licensing opportunities;
- R&D-as-a-Service: creation of customized materials for specific applications.

9. SUMMARY TABLE OF ASIA QUARTZ MATERIALS

Material	Type	Key Property	T, °C	Application
ALEM	SiO_2 ceramic	Purity 99.9%	>3,500	Substrates, refractories
ALEM+	Enhanced SiO_2	Thermal damping	>3,500	Fusion installations
ADIL	Acicular quartz	Purity 99.997%	High	Microelectronics, 5G
ANEL	Carbon sp^2/sp^3	Superconductivity	>4,000	Quantum computing
ALAN M+	Composite	Monolith, 0 Ω	>3,000	AI infrastructure
D16-ALEM	Al composite	Service life ×2–3	300–350	Aviation
ARKTIKA	Steel 09G2S-M	KCU ×4–5, cryo-resistant	to −60	Arctic, cryogenics, oil & gas
StAlem	Ti-Fe-Zr-Os	Absolute inertness	>10,000	Hypersonics, defense

10. CONCLUSION

The Asia Quartz technology platform represents a fundamental breakthrough in materials science, offering solutions to critical problems that were previously considered unsolvable. Key results:

- Overcoming the materials science "thermal wall" (from 3,000 °C to 14,000 °C);
- Industrial-scale production of ultra-pure SiO_2 from technogenic waste;
- Discovery of a natural acicular quartz morphotype from barchan sands;
- Creation of a carbon nanomaterial surpassing graphene in a complex of properties;
- Development of an environmentally safe technology for osmium extraction from copper ores;
- Proposal of a post-silicon architecture for microelectronics.

All developments are at the industrial-prototype stage and are ready for verification in independent laboratories. We invite the global scientific community to collaborate on the validation and implementation of these materials.

Asia Quartz LLP — the first company to establish the technology for transforming accessible natural and technogenic feedstock into the strategic materials of the future.

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