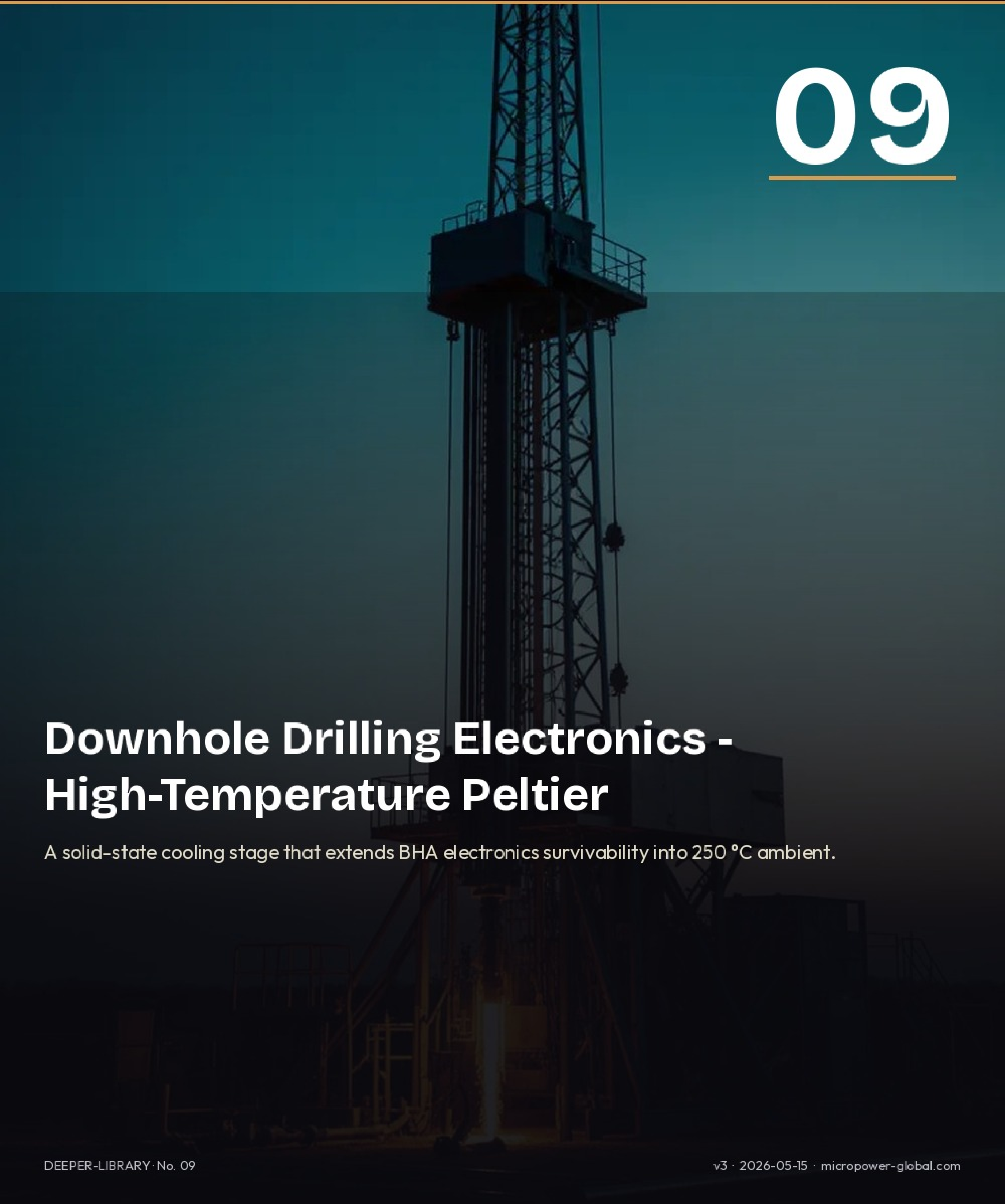

09

Downhole Drilling Electronics - High-Temperature Peltier

A solid-state cooling stage that extends BHA electronics survivability into 250 °C ambient.

v3 · 2026-05-15 · micropower-global.com

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Bottom-hole-assembly (BHA) electronics in modern directional drilling sit at downhole temperatures that destroy commercial Peltier coolers built on bismuth-telluride. MicroPower's high-temperature Peltier modules – the cooling-mode operation of the same chip platform used for high-temperature power generation – are a candidate solution for extending the operating envelope of downhole electronics.

1 · The downhole environment

Modern directional drilling places sophisticated electronics – measurement-while-drilling (MWD), logging-while-drilling (LWD), telemetry, and steering control – within the BHA, only centimetres from the rock face. Downhole ambient temperatures of 150–200 °C are routine; high-temperature reservoirs and geothermal applications push the BHA wall to 250 °C+. Most commercial Peltier cooling modules are built on BiTe and degrade rapidly above 200 °C.

2 · The MicroPower platform position

MicroPower's high-temperature Peltier modules sit between the electronics package and the BHA wall, pumping heat outward. The active cooling extends the operating temperature window of the downhole electronics by approximately 50–100 °C above what passive thermal design alone allows.

What makes the platform usable at downhole conditions is the combination of the chip's PbTe / TAGS material system and the high-temperature contact and thermal-interface structures. The chip's high-temperature contact and thermal-interface structures were informed by an early MicroPower collaboration with the U.S. Army Research Laboratory and have been substantially evolved internally since. Production-spec module performance in Seebeck mode is 14% at 550 °C (extrapolated from ARL's evaluation of MicroPower's standard modules; independently confirmed by NREL against datasheet); the same contact-structure work is what supports Peltier-mode operation at downhole conditions. MicroPower grows its own PbTe and BiTe base semiconductor ingots and builds the modules in-house.

3 · Engineering trade-offs

Active cooling adds parasitic power draw on the BHA's limited downhole power budget. The engineering question is whether the COP at 200–250 °C ambient justifies the parasitic power against the alternatives: derated electronics, GaAs or SiC based circuits with higher temperature ratings, or shortening the directional run.

MicroPower's value proposition in this market is bounded. It is not 'replace silicon' but 'extend the time-on-target window of an existing electronics package — inside its existing thermal rating — with a solid-state, no-moving-parts cooling stage that rejects ambient heat actively rather than relying on passive thermal mass.' The commercial conversation here is with mud-motor and downhole-tool OEMs, not with end-operator E&P customers directly.

4 · Manufacturing readiness

Lab-scale Peltier-mode operation through the temperature ranges relevant to BHA cooling is established on the MicroPower chip platform. A productised, BHA-form-factor MicroPower Peltier module qualified for downhole service is sequential engineering, packaging, qualification, and operator-acceptance work; it is not a catalogue item today.

MicroPower's separately patented MBE-grown energy-sorting barrier-layer architecture multiplies chip-level power density 1.5–1.8× on top of the baseline platform; that figure is from internal MicroPower lab measurement on the prototype barrier layer and is on the post-funding production roadmap, not in production-spec modules today.

5 · Engagement model

MicroPower engages selectively with mud-motor OEMs, downhole-tool integrators, and BHA system designers interested in a solid-state high-temperature Peltier cooling stage co-engineered to a specific BHA platform. Introductions and structured enquiries are welcome via the MicroPower Global contact page.

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