NANODIMENSION

CUSTOMER SUCCESS STORY

KBR

3D Printed Micro-Coil Inspection Sensors

Considerable time and cost reduction can be projected by using Additively Manufactured Electronics (AME) versus hand-wound coils and assembly

Nano Dimension Additive Division

January 2024

The Team Behind the Mission®

At KBR, we partner with government and industry clients to provide purposeful and comprehensive solutions with an emphasis on efficiency and safety. With a full portfolio of services, proprietary technologies and expertise, our employees are ready to handle projects and missions from planning and design to sustainability and maintenance. Whether at the bottom of the ocean or in outer space, our clients trust us to deliver the impossible daily.

KBR is the Team Behind the Mission®, delivering expertise and differentiated, technology-driven solutions in the fields of scientific research, systems engineering, data analytics and mission operations, and we offer a range of high-end services from a portfolio that spans defense modernization; military, civil and commercial space; intelligence; cyber; advanced logistics; and base operations.

With more than 33,000 employees performing diverse, complex, and mission-critical roles in thirty-three countries, KBR is headquartered in Houston, Texas, and generated an annual revenue of $6.6 billion in 2022.

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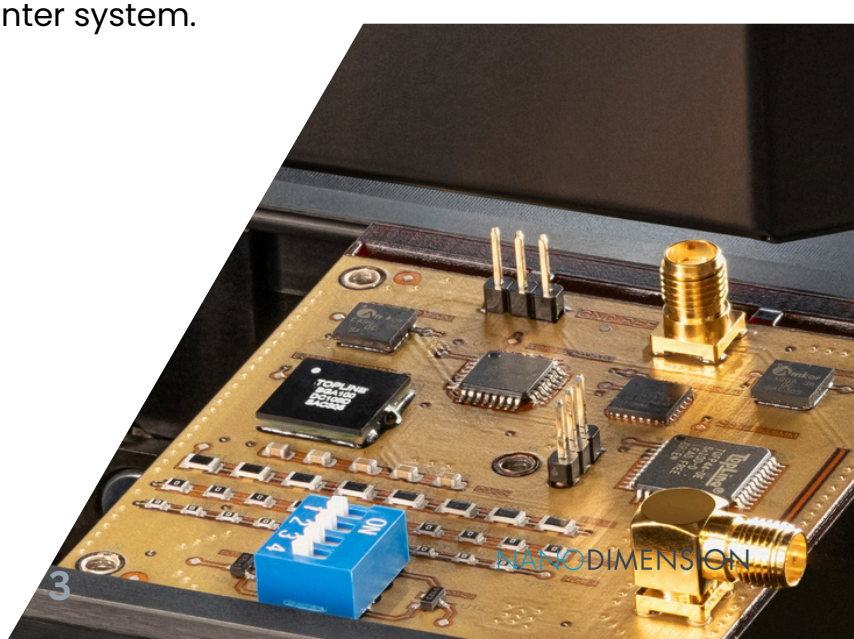
THE CHALLENGES

Physical inspection of Department of Defense (DoD) high-performance aircraft and turbine engines requires exact measurements and is costly and time-consuming. For over 40 years, KBR has developed a world-class in-house capability to produce automated robotic machines with carousels that interchange highly sensitive sensors to measure tiny cracks in mechanical parts during phase inspections. One of the main challenges is the product realization and cost for the different sensors required, as a wide range of sensor sensitivities, sizes, geometries, and allowable tolerances are needed to address critical inspection of the different engine parts and materials.

These sensors often require expensive machining of small, precise mechanical tips, and extensive skilled labor to wind and route very small gage wires onto ferrite cores to create tiny sensor coils interfaced with electronic circuitry. With thousands of these sensors built, and new designs required to inspect new engine parts, our Ph.D. scientists often face demands to provide smaller and more sensitive coils. The concept of affordable 3Dprinted sensor coils integrated as an assembly with the electronics was explored as this technology matured.

In 2019, KBR approached Nano Dimension to explore 3D-printed electronics solutions using the new DragonFly multi-material 3D electronics printer system.



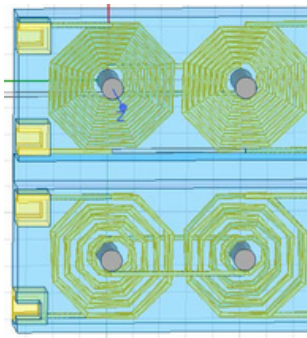
SOLUTION

KBR's Development and Integration Program worked with Nano Dimension to explore their newly developed Dragon Fly 3D electronics printer using dielectric polymer ink and conductive nano-silver ink. Since 2020, KBR experts have explored many 3D-design challenges using this system; comparing performance to standard Printed Circuit Boards (PCB), adaptive circuitry, custom interposers (to address obsolescence issues), tuned RF circuits, 3D antennas for Wi-Fi and GPS, and micro-coils.

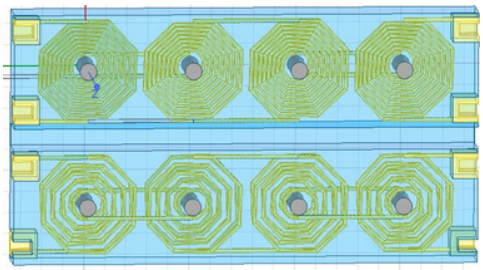
Working with KBR's Ph.D. scientists and engineers who design custom inspection sensors, our engineers have created several different forms of experimental printed 3D micro-coil structures, some with an air core and others with holes for future insertion of ferrite core material. KBR has been successful in printing micro-coils to find the limits, ranging from 0.2 mm up to 5 mm tall on z axis, and from 1 mm by 1 mm wide to much larger sizes on the x and y axes. We have extensively experimented with the numbers and spacing between the windings, and shapes of the conductors. And we have printed varying coil shapes including single and double-wound coils, circular helical coils, double rectangular helical coils, double octagonal conical helical coils, and double square coils. We have also begun experimenting with simplified arrays of various combinations of these coils.

RESULTS

Today, the dominant limitations that 3D printed coils have over hand-built sensors are low conductivity and current, height that limits the number of turns, and holes needed to insert ferrite material. These limitations will be overcome with new materials and methods to enable printing integrated parts as a 3D assembly, with micro-coils, wire traces, active circuitry, and sensor structure.



Besides the sensor coils, we are exploring advances in other multi-material Additively Manufactured Electronics (AME) assemblies to replace the wiring and machined structure and to integrate the coils and electronics. This is traditionally a very expensive machined part with grooves and channels to mount the coils and hand-route tiny wires to the sensor electronics. We are assessing 3D-printed ceramic parts for the sensor's structure and printed copper traces to replace the wires.



As an early adopter, KBR has worked with Nano Dimension through each product and beta release. Throughout this process, Nano Dimension has provided KBR with outstanding customer support. This has enabled KBR to explore new and novel 3D parts, develop lessons-learned and be ready for the future.

> *KBR historically builds sensitive miniature sensors by hand that are used to inspect military aircraft and turbine engine parts. With our DragonFly, we are advancing new ways to 3D print and test micro-coils today. With new materials and methods planned, we are researching ways to integrate the coils, conductive traces, and electronic circuitry embedded with the sensor's mechanical structure. If this capability leap can be achieved, we can rapidly develop and produce new sensors at reduced costs, giving KBR a significant competitive advantage."* — **Wayne Devereux, KBR Senior Program Manager**

Effortless In-house Prototyping

DragonFly IV

The DragonFly IV is a cutting-edge 3D printer redefining how electronics are designed and manufactured. As a multi-material, multi-layer additive manufacturing system, it enables the creation of entire circuits in a single print—integrating substrates, conductive traces, and passive components seamlessly. With the DragonFly IV, engineers and designers can move beyond the constraints of traditional electronics fabrication, unlocking unprecedented design flexibility and enabling a completely new way to build complex, customized electronic devices.