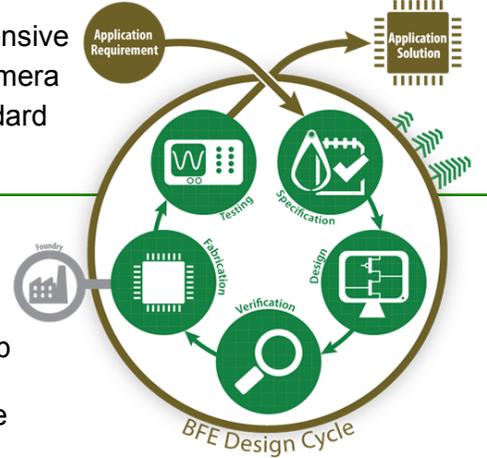


# Black Forest Engineering

a wholly-owned subsidiary of  
**LUMINAR**



We are a leading innovator of pixel-based sensors and displays with extensive expertise in IC based readout of IR, visible, and X-Ray detectors, and camera integration. We design, test, and provide consulting services for nonstandard



## Primary IC Design Services

As a full service custom mixed-signal ASIC design house Black Forest Engineering helps customers of all sizes with everything from the initial IC specification all the way to providing a functional test system. We help ensure that the specification is complete and meets your system's requirements. We recommend the optimal foundry/process to manufacture your ICs. We manage the foundry and packaging logistics. We test the

## Applications

IR detectors / preamplifiers / multiplexers  
Micro-power A/D and D/A converters  
X-ray and high energy particle detectors  
Radiation hard versions of above  
Image sensors (CMOS and CCD)  
Image processors  
Integrated liquid crystal drivers

## Custom Test Systems

*Performance built for your specific requirements.*

Wafer probing  
Testing at cryogenic temperatures  
PCB designs and interfaces using FPGA, CPLD and a variety of other components  
Solutions for system interface problems:  
High density interconnect  
Non-standard packaging

## Chip Extremes

### Size

**300um** diameter die size imagers for medical applications  
**17x19 mm<sup>2</sup>** display driver for projection displays  
**148.5 x 28.8 mm<sup>2</sup>** visible/scintillator x-ray sensor (using stitching)

### Special Features

As high speed as **2Ghz** analog bandwidth CMOS for LIDAR range sensing  
Down to **single photon** detection  
**22V** CMOS devices  
From far infrared to high energy particle readout processors

### Environments

Operational in a 40 Kelvin environment  
Radiation hardened at cryogenic temperatures  
Radiation hardened up to 3 Mrad TID  
Flown uncooled LWIR in a UAV at 500ft AGL

### Summary

From long wave infrared to high energy X-ray,  $-233^{\circ}$  C to  $125^{\circ}$  C operating temperature, and radiation hardened to 3 Mrad TID we have the design expertise to meet your needs no matter how challenging and unique they may be.

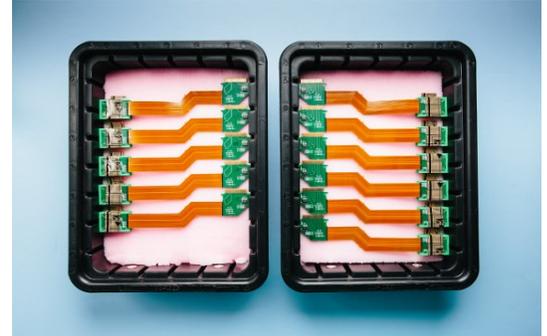


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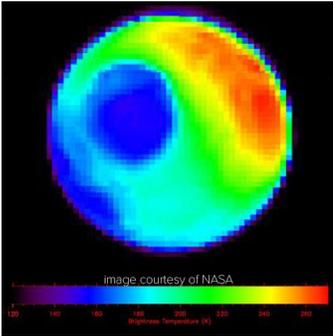
## LiDAR/Visible

BFE designs 1D and 2D LiDAR arrays for both military and commercial applications. BFE LiDAR ASICs are designed for performance and function at speeds up to 2GHz analog bandwidth. They have achieved wide dynamic ranges with ultra-low noise analog and digital circuitry sensitive enough to detect down to a single-photon. BFE has implemented a variety of supporting circuitry on the same LiDAR ASICs such as temperature sensors, filters, high precision parallel time to digital converters, analog to digital converters, discriminators, and high speed digital outputs negating the need for complex and expensive supporting components.



This image shows our custom ROICs in a LiDAR receiver

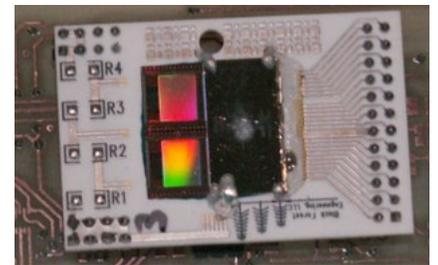
## Infrared



BFE has designed over 100 ROICs for both cooled and uncooled infrared detector types with both analog and/or digital outputs. We have successfully demonstrated digital ROIC operation in multiple types of radiation environments and in temperatures as low as 40 Kelvin. The image at left is courtesy of NASA and was produced by the Mars Climate Sounder Instrument during calibration on Mars approach. The instrument uses a JPL thermopile array and a BFE designed readout chip. The instrument is still functioning normally after more than a decade in Martian orbit.

## X-ray

Our projects include a radiation-hard, high-energy x-ray and particle detector with a range of 0.5 - 600 keV. Programmable pixel circuitry allows for a wide range of detector capacitance with a noise of less than 30 electrons. This image shows our ROIC and detector, which can tolerate over 500 kRad, developed for use at NASA.



## Contact BFE

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*We enjoy providing successful solutions to the most difficult problems.*

