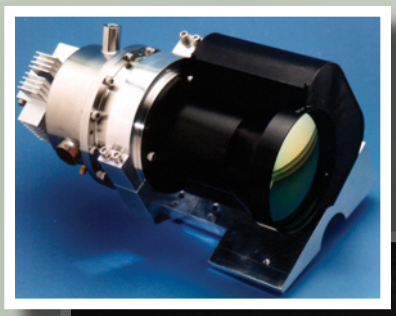
Nano-Layer Midwave Infrared Detectors and Cameras

Accomplishment: This research produced the world's first successful 'staring' (continuous imaging) infrared sensors by developing a two nanometer thick platinum silicide (PtSi) layer on a silicon substrate. The basic research to establish the process of internal photoemission responsible for the infrared signal was developed and transitioned into production of an infrared camera technology that dominated the field for more than a decade.

Impact: AFRL PtSi research revolutionized the field of infrared imaging and target detection. Field testing established the midwave infrared band as the international industry standard for long-range imaging through the atmosphere. PtSi infrared cameras dominated the field for almost 15 years since the early 1990s, when they were used in U-2 aircraft during the Gulf War. These cameras were installed in the entire B-52 fleet in the 1990s, giving a 50-fold increase in reliability and a three-fold increase in the warning and detection range relative to preceding infrared cameras. The increased reliability saved the Air Force $12 million per year by reducing maintenance costs in the B-52 fleet. As a result of this accomplishment, the leader of the PtSi effort was elected to the National Academy of Engineering and was awarded numerous engineering and professional society awards.



Motivation and Approach: Previous infrared sensors gave images by scanning a single pixel or a line of pixels over the area of interest. As a result, the detector spent little time on specific points of interest and the final image had to be reconstructed. By contrast, staring sensors allow the entire image to be collected at once, similar to taking a conventional photograph. The use of commercial silicon technology and the low electronic noise of the photoemission process increased the signal to noise ratio in the image. This greatly improved the reliability of information in the image, and opened up new image processing techniques that remain in use today.

To achieve this capability, thin PtSi films were created on silicon to absorb infrared radiation with a wavelength from 3-5 μm, producing an electronic signal at the PtSi/silicon interface by internal photoemission. The maximum efficiency of these devices occurs when the PtSi layer is only two nanometers thick. The AFRL team discovered and leveraged this behavior to create infrared cameras, and they also invented infrared image processing and calibration methods that maximized the camera's detection capabilities. Many of these techniques were adopted throughout the international infrared community, and are now used for detection in all wavelength bands and by a variety of sensors. Fabrication was transferred to commercial production at US silicon wafer manufacturers. PtSi/silicon cameras were installed in the U-2 during the Gulf War, where they were used to locate and identify placement of land mines and other targets of military interest. PtSi/silicon cameras were installed in the entire B-52 fleet in the 1990s – the prototype was built in-house by the AFRL research team.

Team: The research team at the Sensors Directorate and its predecessor organizations was led by Dr. Freeman Shepherd, with major contributors from Charlene Caefer, Steven DiSalvo, Dr. William Ewing, Darin Leahy, Charlotte Ludington, Dr. Jonathan Mooney, James Murrin, Paul Pellegrini, Dr. Jerry Silverman, Virgil Vickers, Melanie Weeks, and Dr. Andrew Yang. The basic research was funded by the Air Force Office of Scientific Research and the development and industrial transition was funded by the Sensors Directorate.