



**QUEEN'S
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BELFAST**

CWI

**CENTRE
FOR
WIRELESS
INNOVATION**

FREQUENCY SELECTIVE SURFACE FILTERS FOR EARTH OBSERVATION REMOTE SENSING INSTRUMENTS

Need

Major advances made in space borne Earth Observation instrument technology, primarily to address the need to study the processes driving the climate and to monitor its changes, have required complex imaging of clouds and spectroscopic characterization of carbon dioxide and other greenhouse gases in the Earth's atmosphere, using remote sensing instruments (such as radiometers).

To satisfy satellite payload constraints on cost, mass and energy consumption, passive Earth Observation radiometers traditionally employ a single mechanically scanned aperture antenna to simultaneously collect radiation in several different frequency bands. Frequency selective surface (FSS) demultiplexing elements are a key enabling technology for these advanced instruments, and are used in the quasi-optical receiver to spectrally separate the signals that are collected by the antenna. The key technology need is for FSS that exhibit very low signal band insertion loss, and simultaneously meet the conflicting requirement for high isolation between adjacent frequency bands. This is necessary to minimize the overall noise performance of the instrument, and thereby achieve high receiver sensitivity to detect weak molecular emissions at microwave -THz wavelengths. The FSS should also be sufficiently robust to withstand the launch forces of the space vehicle and operate without failure in the harsh thermal environment in orbit.

Approach

We have created a new class of printed and substrateless FSS that satisfies the electromagnetic requirements for remote sensing instruments that have entered service since 2005. In addition to the use of new micromachining technology, innovative electromagnetic design strategies and measurement techniques have been employed to create quasi-optical filters, which can separate either linear or simultaneously separate vertical and horizontal polarized components of naturally occurring thermal emissions, with spectral efficiencies exceeding 93% at frequencies up to 700 GHz.

This new class of FSS was developed for the preparatory breadboarding of the MARSCHALS airborne limb-sounder (294–380 GHz), European Space Agency (ESA) dual polarization FSS technology demonstrator (316.5–358.5 GHz), Microwave Imager (MWI) instrument (113–670.7 GHz) and Microwave Sounder (MSI) Instrument (29–229 GHz). MWI and MWS are payloads which are currently under development for the European Post EPS mission.

We have also invented two new innovative electronically tunable FSS structures: one FSS variant provides conversion from linear to circular polarization, whereas the other structure exhibits electronic shutter operation by exploiting the dielectric anisotropy property of nematic state liquid crystals.

Results

1. First-ever detection of all the different frequency channels by a single antenna MetOP-SG MWS radiometer, thus halving the footprint of the satellite payload.
2. We have developed the first ever ultra-low loss space qualified dual polarisation FSS, which provides enhanced functionality and radically simplified radiometer architecture.
3. Delivery of four different FSS during the preparatory breadboarding stage of the MWS Instrument development programme, part of the MetOP-SG mission funded by the European Space Agency. When launched in 2020 this will be the world's most advanced meteorological data acquisition system.

Publications

'THz Frequency Selective Surface Filters for Earth Observation Remote Sensing Instruments.'
Authors: Dr Raymond Dickie, Dr Robert Cahill, Prof. Vince Fusco, Prof Harold S. Gamble, and Dr Neil Mitchell. Published in IEEE Transactions on Terahertz Science and Technology (2011) pp. 450 – 461, doi: 10.1109/THZ.2011.2129470.

Patents

1. Improvements in or Relating to Frequency Selective Surfaces, R Dickie, R Cahill, H Gamble and V Fusco: United States Patent Application No 11/908678, Issue Date, April 2011
2. Improvements in or Relating to Frequency Selective Surfaces, R Dickie, R Cahill, H Gamble and V Fusco: European Patent Number EP1861896, Issue Date, May 2010 and US 7,982 686 B2, 2011
3. Frequency Selective Surfaces for Separating Multiple Frequencies, Cahill R: US Patent Number US6208316. Issue Date, March 2001
4. Frequency Selective Surfaces, Cahill R: European Patent Number EP0711001. Issue Date, May 1996

Researchers

QUB:

Dr Robert Cahill – r.cahill@qub.ac.uk
Dr Raymond Dickie
Dr Neil Mitchell
Prof Vincent Fusco
Prof Harold S Gamble (now retired)

Commercial contact

Norbert Sagnard – n.sagnard@qub.ac.uk

Technology readiness level

TRL 8: 'Flight qualified' – Performance has been demonstrated in Earth environment and on aircraft and space, qualified for thermal and vibration.