National Aeronautics and Space Administration

360° MEMS phase shifter for wide angle beam scanning phased array antennas

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Program: FY22 R&TD Innovative Spontaneous Concepts

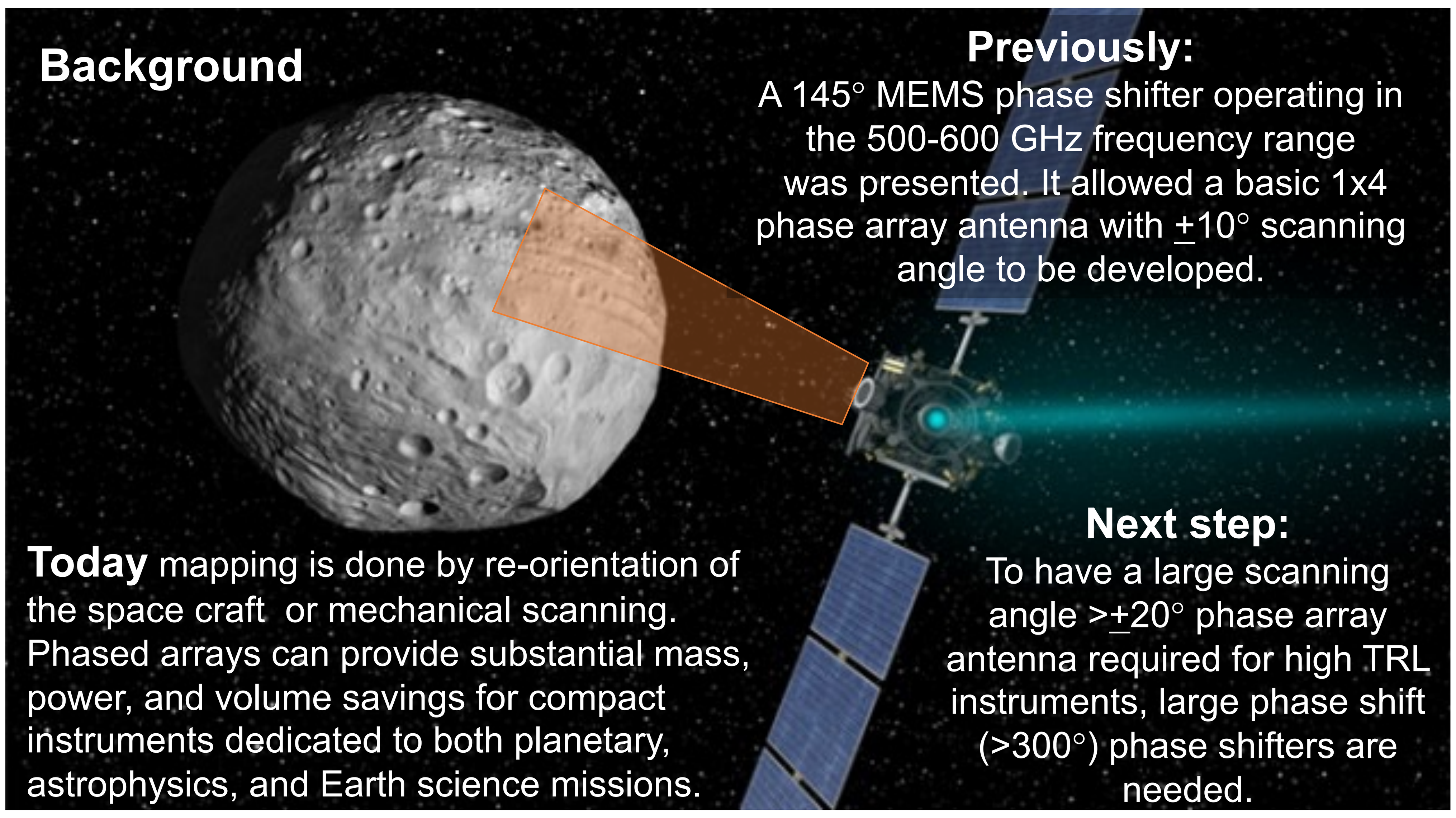
Objectives:

- Design a dielectric slab that will:
  - create a large phase shift (more than 300°)
  - keep the reflection low
  - be incorporated with a MEMS motor
- Enable wide-scanning phased array antenna for rapid surface scanning in search for H_2O (557 GHz) and HDO (599 GHz).
- Once mature, these components can be used for astrophysics and Earth science instruments as well.

Significance/Benefits to JPL and NASA:

These phase shifters can enable wide scanning phase array antennas order to detect the ortho-water ground state line at 557 GHz and measure other species in the planetary atmosphere. Once mature, these components can be used for astrophysics and Earth science instruments as well.

Background



Previously: A 145° MEMS phase shifter operating in the 500-600 GHz frequency range was presented. It allowed a basic 1x4 phase array antenna with ±10° scanning angle to be developed.

Today mapping is done by re-orientation of the space craft or mechanical scanning. Phased arrays can provide substantial mass, power, and volume savings for compact instruments dedicated to both planetary, astrophysics, and Earth science missions.

Next step: To have a large scanning angle >±20° phase array antenna required for high TRL instruments, large phase shift (>300°) phase shifters are needed.

Approach and Results:

- A silicon hexagon pattern was designed to load the waveguide enough to create a large phase shift, Fig 1.
- Depending on the Si-to-Air ratio, different effective permittivities can be achieved, Fig 1.
- By adding transition permittivities on each side of the center permittivity, the reflection can be lowered, Fig 2.
- Depending on the position of the dielectric slab, different phase shift can be achieved, Fig. 2.

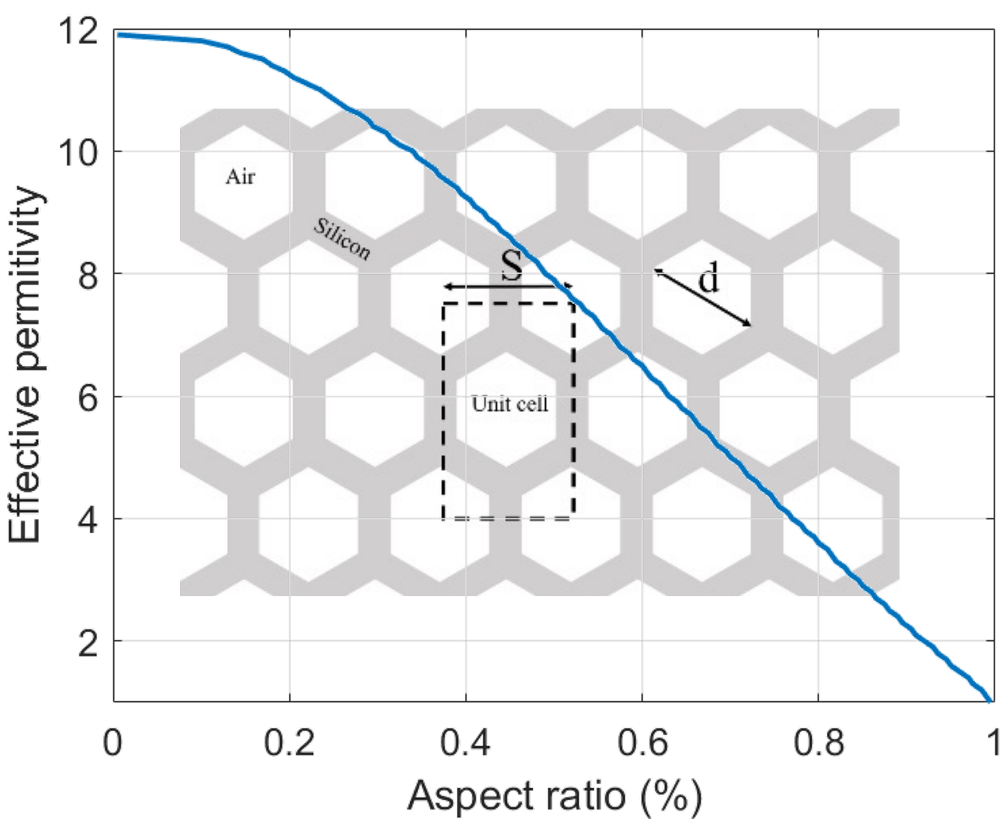


Figure 1: Effective permittivity depending on the Si-to-air ratio. Hexagon pattern demonstrating unit cell.

The dielectric slab was incorporated with a MEMS motor design and fabricated in the MDL cleanroom

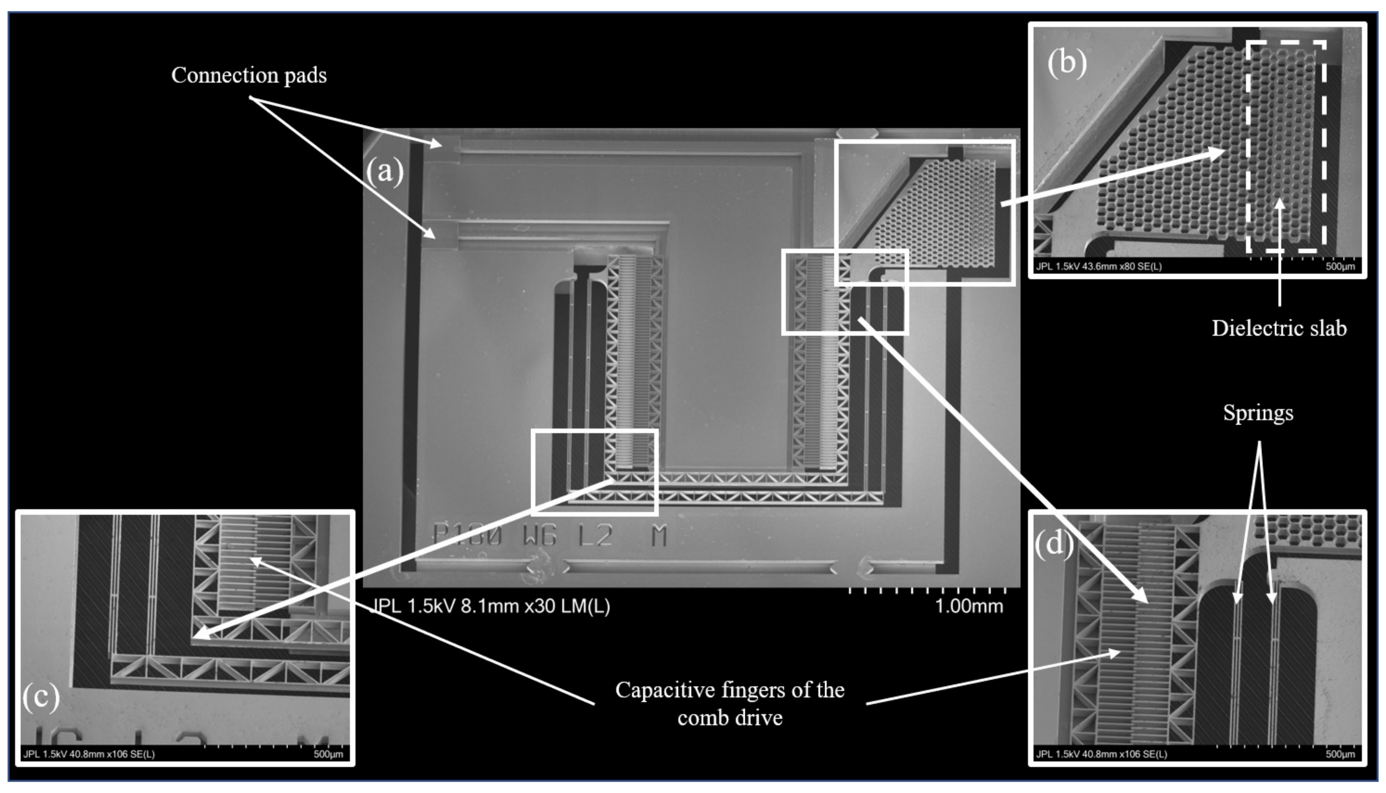


Figure 4: a) SEM image of a fully fabricated phase, b) close up of the dielectric slab, c) close-up of the comb-drive, moving the slab and c) close up of the spring controlling the movement.

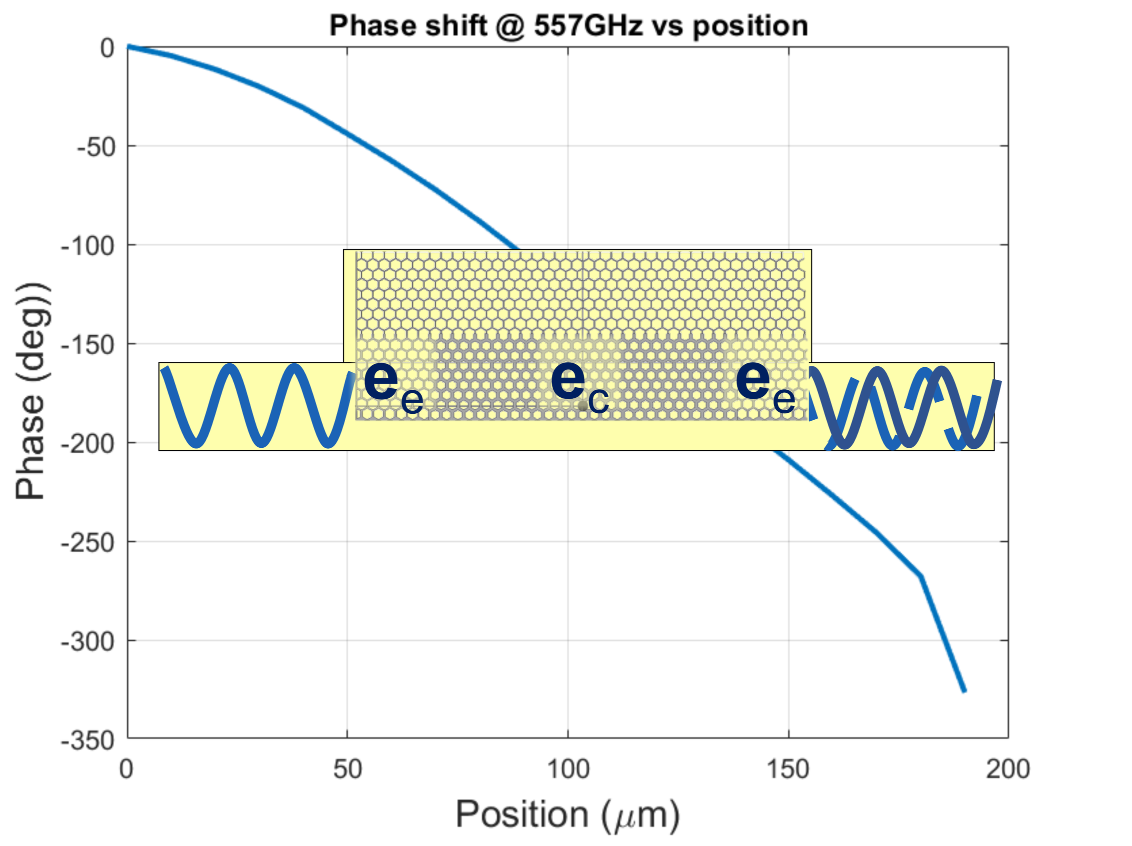


Figure 2: Graph of phase shift depending on insertion position inside the waveguide. Schematic figure of waveguide with dielectric slab

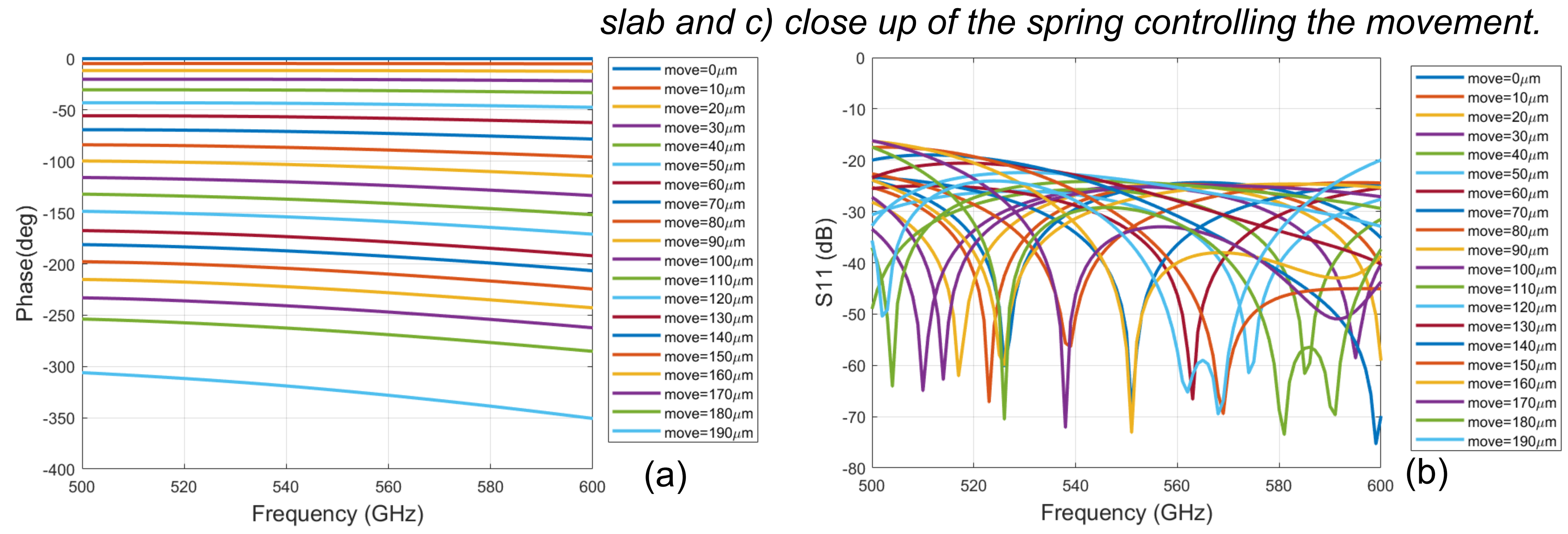


Figure 3: a) Simulated total phase shift throughout the band (500-600 GHz) and b) simulated reflection coefficient through out the band for different positions in the waveguide. At 557 GHz the phase shift is 325° and the reflection coefficient is -24 dB

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Clearance Number: CL#
Poster Number: RPC#R22231

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