High Frequency Signal Processing Devices for Security Applications: Band Pass and Notch Filters

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The Need

- **To see through fog, clouds, and smoke**
- **To improve cell phone and emergency communications with compact signal processing devices**

The Problem

- Visible light and infrared radiation are blocked by fog, clouds and smoke.
- Cell phone and emergency communication technology is moving to higher frequencies.

The Solution

Use microwaves and millimeter waves

Fog, clouds and smoke are transparent for electromagnetic waves at particular frequencies in the GHz range

Applications

1) Tracking planes, missiles or ships
2) Tracking people near sensitive installations in severe weather conditions.
3) Viewing battlefield under smoky conditions

What is needed?

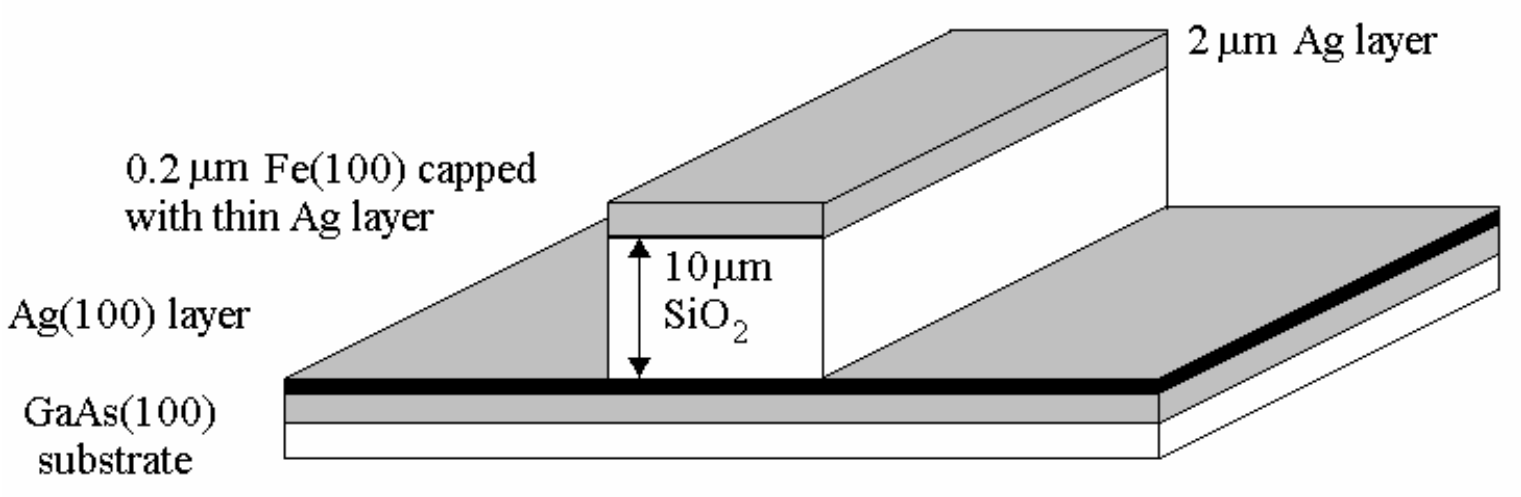
Methods to deal with electromagnetic signals at these **high frequencies** and signal processing devices which are of **compact size**

1) Notch filter – eliminates signals at particular frequencies

2) Band pass filter – allows signals at only one frequency to be transmitted

1) Phase shifter – changes the signal slightly to allow mixing with other signals

Current Work: Notch Filter



Structure grown using Molecular Beam Epitaxy and sputtering and then patterned by photolithography and etching

How It Works: Notch Filter

Magnetic materials have a natural oscillation frequency that depends on the applied magnetic field and on the internal magnetization

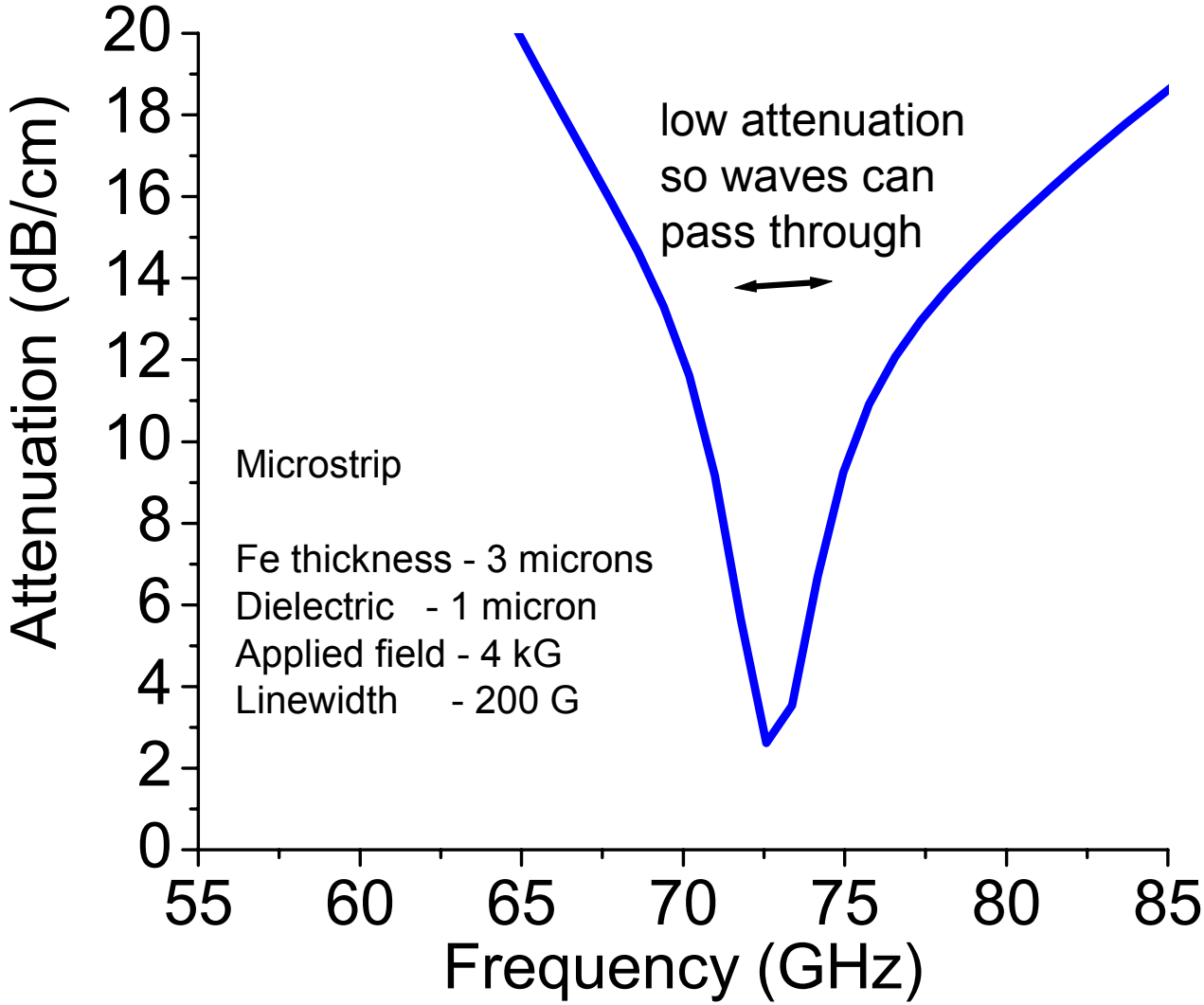
$$\text{frequency} = \gamma\sqrt{H(H + 4\pi M)}$$

H = applied magnetic field

M = magnetization

When the electromagnetic wave is at the same frequency as the natural (or resonance) frequency – it is easy to transfer energy from the wave to the magnetic material. So the wave gets attenuated.

Notch Filter – Theoretical Results

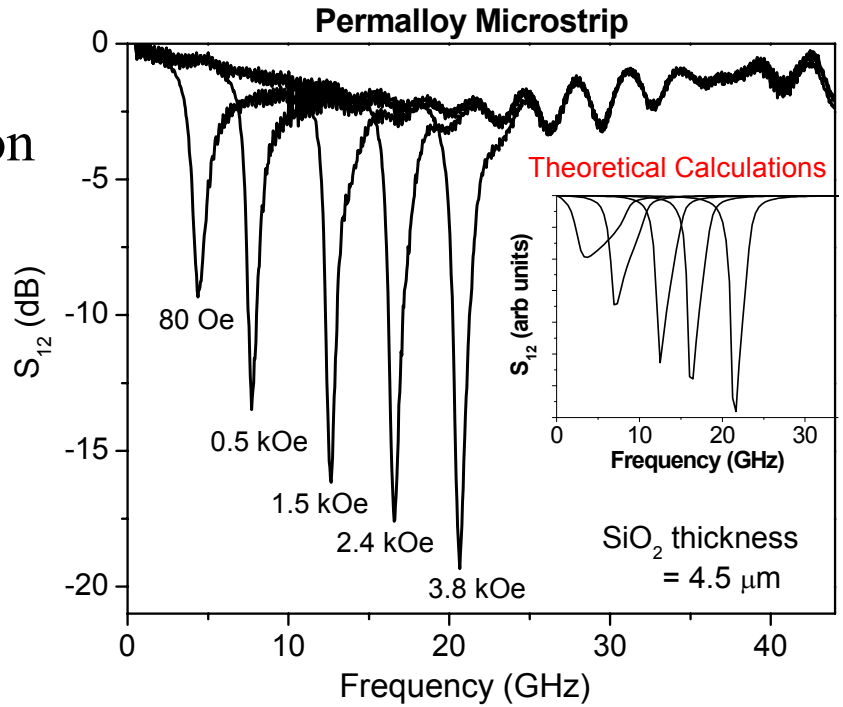


Results for Notch Filter - Permalloy

Experimental Results on Permalloy Microstrip Waveguide
grown by sputtering (0.3 mm in length)

Key Features:

1) Very deep power attenuation over 100 dB/cm
2) Bandwidth – 1 GHz
3) Low insertion loss
4) Operation range 5-20 GHz
5) Sputtering is compatible with normal IC fabrication



Results for Notch Filter - Iron

Experimental results on Fe microstrip waveguide

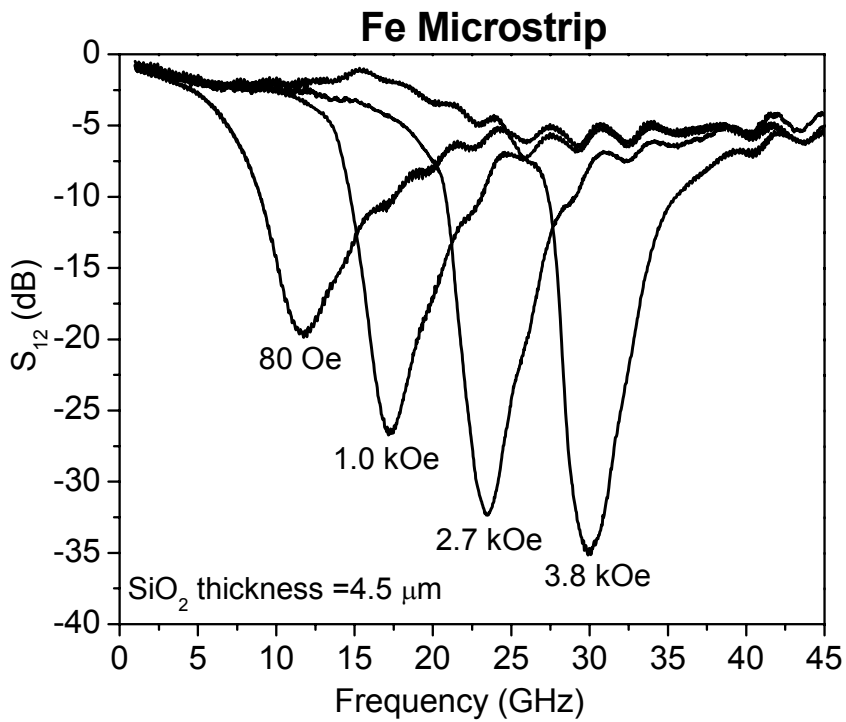
(0.3 mm in length)

Key Features:

1) Shape anisotropy of magnetic element produces **large** anisotropy which boosts frequency to 10 GHz at zero field

2) Power attenuation is large – 180 dB/cm

3) Operation at 30 GHz with a field of only 3.8 kOe



Summary

1) There is an important need for signal processing at high frequencies for security applications
2) High magnetization materials have natural frequencies in the 10-30 GHz region
3) We have made initial devices (notch filters) to perform signal processing at these high frequencies
4) More work is needed to create other signal processing structures. We have begun work on band pass filters.
5) Notch filter results have been published:
    1) "High Frequency Band Stop Magnetic Filters" B. Kuanr, Z. Celinski and R. E. Camley, Applied Physics Letters 83, 3969 (2003).

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