Improving spectral utility requires preserving spectral information

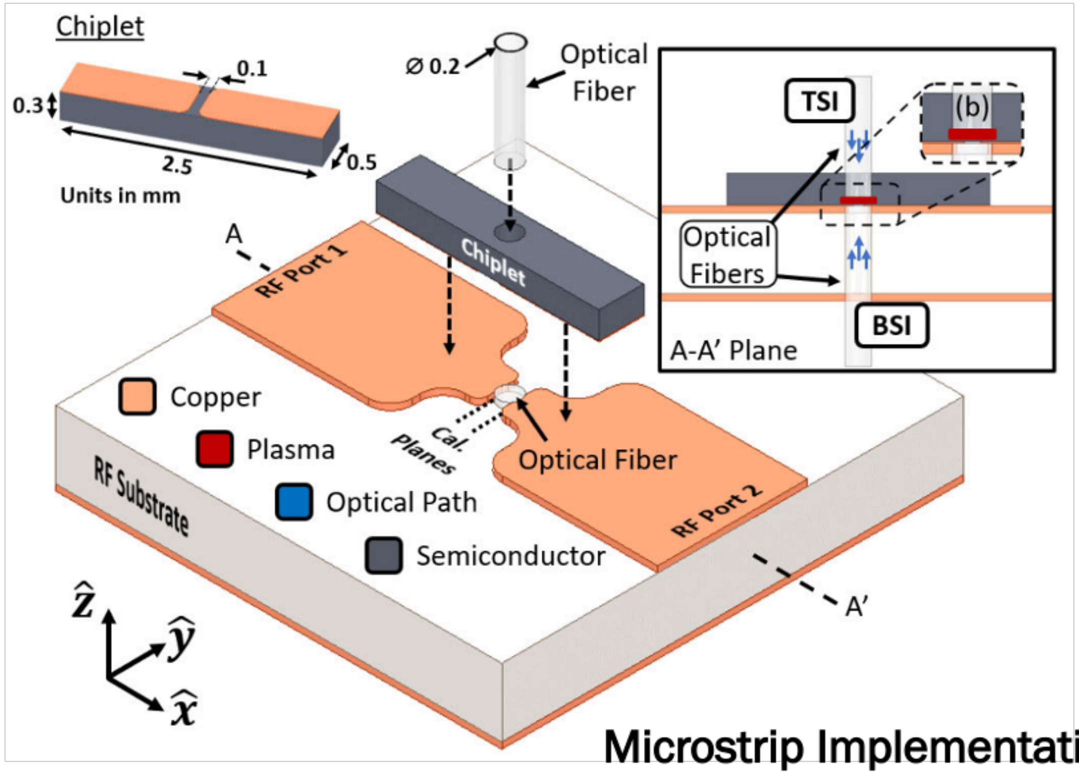
- **Prof. Patrick McCormick - University of Kansas**
  - RF signal processing, interference mitigation, wideband direct RF spectral monitoring, emission design for spectral cohabitation
- **What do we want?**
  - **Improved spectral utility**
    - Increased spectral agility of systems enables dynamic spectral access and sharing of spectral resources between RF systems
  - **Spectral sense-making**
    - Spectral utility will be enabled by our ability to monitor and make sense of the spectral environment
- **What do we need to get what we want?**
  - **Broadband spectral monitoring**
    - Capture and "digest" wide RF bandwidths with maximal preservation of information via RF chain and distillation of information via DSP
  - **Interference management and mitigation**
    - Coordinate with other spectral users and be robust to radio frequency interference (RFI)
  - **Efficient access of the spectrum**
    - Rapid generation of spectrally "clean" emissions with low risk of collision with other users
- **What are the challenges?**
  - **Preservation of "information" (RF reception):**
    - Sufficient dynamic range to capture aggregate signal environment
    - Linearity of components across wide BWs and high dynamic range
    - System noise temperature, antenna efficiency, impedance matching, and frequency-dependent gain/noise variation.
  - **Distillation of "information" (RF DSP):**
    - The data "firehose" – high-speed transceivers result in more power-hungry DSP and push what is feasible to process within reasonable timelines
    - System latency and trustworthiness of AI/ML data processing
  - **Generation of "information" (RF transmission):**
    - Power amplifier efficiency, linearity, bandwidth, and output power
    - Harmonics, intermodulation products, and other out-of-band emissions
- **What are the enabling technologies?**
  - **Software-defined architectures**
    - Open-source software frameworks enable rapid prototyping
  - **Fully digital arrays**
    - Spatial selectivity for spectrum monitoring, access, interference mitigation
    - Multiple tx/rx channels alleviate single channel gain requirements
  - **High-rate multi-channel direct RF transceivers**
    - AMD Versal RF, Intel Agilex 9, ADI Apollo MxFE
  - **Adaptive and reconfigurable RF front-end components**
    - Frequency selective limiters (Metamagnetics "Auto-tune filter")

– $E_{optical} \geq E_{BG}$ => photon energy greater than bandgap

–Semiconductor transitions from dielectric to a conductive state (**solid-state plasma**)

- Demonstrated advantages
  - Simple, integrated, low cost
  - High speed and high power performance
  - DC bias network isolated from RF signal
  - Wide bandwidth from DC to beyond 100 GHz

Low Insertion Loss[2]	< 0.22 dB from DC–110 GHz
High Power Handling[3]	>100 W @ 3 GHz
Hot Switching[3]	>30 W @ 3 GHz
Fast Switching Times[3]	< 3.5 μs @ 3 GHz
High linearity[4]	IIP3 >78.5 dBm @ 2 GHz



Microstrip Implementation[3]

1. Fisher *et al.*, *IEEE IMS*, Jun 2021
2. Fisher *et al.*, *IEEE IMS*, Jun 2022
3. Fisher *et al.*, *IEEE T-MTT*, Jan 2024
4. Pang *et al.*, *IEEE IMS*, Jun 2018

State-of-the-art performance for new and emerging applications!

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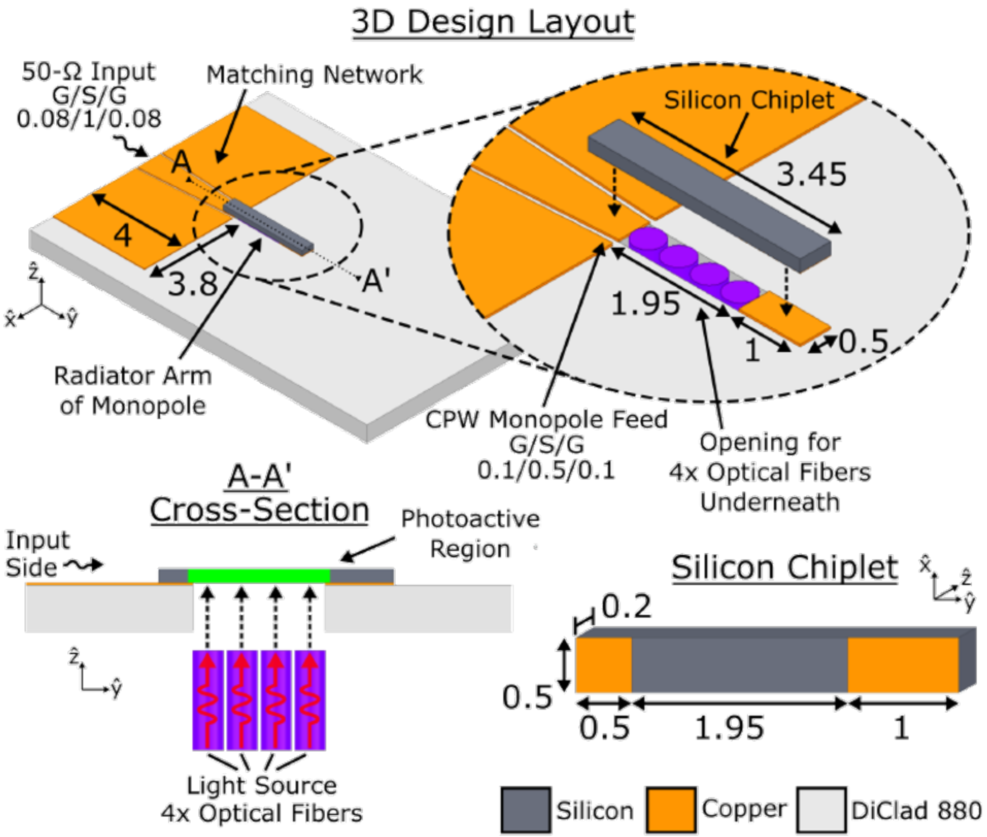
Photogenerated Si Plasma Antennas

- **Concept**
  - Utilize the photoconductive solid-state plasma effect within a piece of high resistivity silicon as the radiator arm of a monopole antenna
- **Advantages**
  - Simple, integrated, and low-cost
  - Reasonable broadside realized gain >-3 dBi
  - Large ON/OFF ratios >18 dB
  - Potential for reconfigurable array applications



With no light applied, the antenna is effectively indistinguishable from typical substrates

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