# Double Metal Quantum Cascade Laser with 2D Patch Array Antenna on a BCB Substrate with Gaussian Beam Shape for Local Oscillator Applications at 1.9THz

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Double metal waveguide QCLs are attractive for applications because of their low power dissipation and good c.w. operation properties, especially at lower operation frequencies. Due to the sub wavelength facet dimensions, the farfield of these devices is generally very poor. An on-chip 2D patch antenna array dramatically improves the farfield and allows high power coupling to free space.

2x2 parallel fed and 3x3 serial fed patch antenna arrays on a benzocyclobutene (BCB)polymer layer are combined with a70µmwide, dry etched, double metal waveguide quantum cascade laser, operating at about 1.9THz. The BCB surrounds the QCL ridge and is planarized to fit precisely its height.

The low dielectric constant ($\varepsilon_r$=2.45) and the high thickness (h = 13.6µm) of the BCB substrate allow a very wide operation bandwidth of the antennas (1.7…2.1THz). On the other hand, under these conditions special care has to be taken in the design of the microstrip power- and phase- distribution network of the array to avoid losses due to surface waves. We achieve a total antenna efficiency of 70…75% where half of the losses can be attributed to the losses in the BCB substrate.

The patch antenna arrays emit anarrow,highly symmetric beam perpendicular to the antenna plane. The beam has a (power) FWHM angle of 48°(2x2) and 29°(3x3). We calculate a very high beam Gaussisity of ≈90%. The measured beam shape and Gaussicity agree very well with the simulations. The high beam quality is important for the use of the QCLs as strong local oscillator source in multi pixel heterodyne receiver setups at THz frequencies.

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