Monolithic focal plane array concept for space and ground applications

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***Abstract*—Single pixel heterodyne receivers has been a common for ground based and especially for space based applications in mm/submm wavelengths. Arranging receiver pixels in a Focal Plane Arrays (FPA) is the next step in improving observing efficiencies in many observing tasks. While development of FPA's has been successful for balloon and airborne projects, the main problem for achieving large pixel count has been the cost per pixel. Typically FPA is constructed out single array pixels which are typically assembled and tested separately. This leads to relatively large handling and testing costs in addition to cost of an optical element which is either lens or horn. We propose an array concept which combines a silicon lenslet array technology, that has been demonstrated with an antenna coupled microwave kinetic inductance detector arrays with a planar array of antennas, fabricated on the same chip. With F/D ratios in the range of 1.7..2.5 the array size limited by 2 F lambda/D will be of order of several millimeters which allows for dramatic decrease size, weight and of the cost per pixel of the RF part of an FPA.**

Keywords—Focal Plane Array, Silicon Lens, Aplanatic Lens, Heterodyne Mixers

I. INTRODUCTION

Single pixel heterodyne receivers has been a common for ground based and especially for space based applications in mm/submm wavelengths. Arranging receiver pixels in a Focal Plane Arrays (FPA) is the next step in improving observing efficiencies in many observing tasks. In fact, practically all space mission proposals dealing with high resolution spectrometers discuss exclusively FPAs. While development of FPA's has been successful for balloon and airborne projects like GUSSTO and SOFIA, the main problem for achieving large pixel count has been cost per pixel which is driven by adopting a combination single pixels into a FPA configuration. These single array pixels are typically assembled and tested separately prior to integrating to an FPA structure. This leads to relatively large handling and testing costs in addition to cost of an optical element which is either lens or horn.

We propose to revisit a monolythic array concept which combines a silicon lenslet array technology with a planar array of antennas, fabricated on the same chip. The silicon lenslet array technology has been recently developed and demonstrated with an antenna coupled microwave kinetic inductance detector arrays. Large lenslet arrays can be manufactured in one technological cycle by a laser evaporation technique. Lenselet arrays of several thousand pixels has been successfully produced with very small cost per pixel. One limitation of this technology is that manufacturing time and cost per pixel is proportional to a volume of material which needs to be removed to form the lenslets. This leads to a relatively small lens diameter and thus to a large beam divergence. Lenslets of only several wavelengths size has been demonstrated to work efficiently.

With F/D ratios in the range of 1.7..2.5 the array size limited by 2 F λ/D will be of order of several millimeters which allows for a dramatic decrease of the cost per pixel of the RF part of an FPA. An example of array/chip profile calculated for F/D=1.72 is shown in fig. 1. The array raw size calculated for 650 GHz central frequency is only 4 mm. This means a rectangular array of 9 pixels will use only 4x4 mm chip size which is pretty common for a single pixel planar heterodyne mixer. Since cost of detector wafer fabrication is fixed, cost per detector is inversely proportional to detector chip area, so the proposed approach allows to decrease production costs 9 times for a given example. This number does not take into account yield considerations

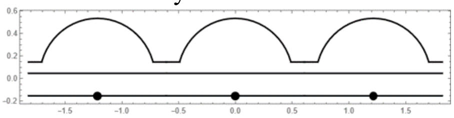

Fig. 1. Cross section of one array raw, showing silicon lens profile (top), array chip (bottom) and planar antenna positions (large dots).

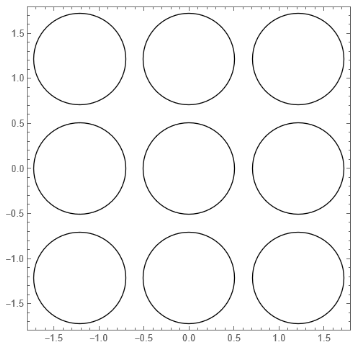

Fig. 2. Cross section of one array raw, showing silicon lens profile (top), array chip (bottom) and planar antenna positions (large dots).

We will discuss optical configuration and realizable chip layouts, including IF distribution, RF cross talk, aperture efficiency and application for both SIS and HEB technology.

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