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研究課題名（和文）回折限界を打破する偏光ホログラムメモリシステムの研究開発

研究課題名（英文）Polarization holographic storage system in order to overcome the diffraction limitation of light

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研究成果の概要（和文）：　近年、ホログラムストレージシステムやホログラフィック集積回路（光再構成型ゲートアレイ）の研究が急ピッチで進められている。このようなシステムの場合、イメージセンサの解像度を高くすることでさらにバンド幅を高くできるが、回折限界から、これ以上の高いバンド幅での読み出しが難しくなっている。そこで、本研究では、回折限界に達したスポット径をこれ以上小さくする試みをやめ、１つのスポットから偏光状態を読み取り、複数ビットの情報として活用できる偏光ホログラムストレージシステムを開発した。

研究成果の概要（英文）：Recently, researches of holographic storage systems and very large scale integrations using a holographic memory technology or optically reconfigurable gate arrays are being done. Under such researches, although the bandwidth of a reading operation can be improved by increasing the resolutions of its image sensors, the improvement is not easy because the spot size has already reached the diffraction limitation of light. Therefore, in this research, in order to extract some bit information from a single spot, we have developed a polarization holographic storage system which can read the polarization angle from a spot generated from a holographic memory.

研究分野：情報学

キーワード：ホログラムメモリ　DLP　MEMS　偏光

１．研究開始当初の背景

我々はMEMS(Micro Electro Mechanical Systems)ミラーアレイとレーザアレイのハイブリッド構造を採り、それらにインターリブ方式を適用することで超高速な読み出しが可能な非回転式のホログラムストレージシステムを開発している。このストレージシステムでは例えば10μsで応答する200万個のMEMSミラーアレイを用い、10nsで応答する1000個のレーザアレイをそれらに組み合わせ、ホログラムメモリのアドレッシングをインターリブ方式で行ない、100万画素のイメージセンサでホログラムメモリからのページデータを10ns周期で読み出すものとすると25TBのホログラムメモリをわずか2秒で読み出すことが可能になる。この読み出しスピードは既存のブルーレイの約70万倍のスピードに相当する。

しかしながら、非回転式のホログラムストレージシステムではホログラムメモリの位置を変更すること無くデータを読み出すことから、ホログラムメモリとイメージセンサ間の距離が増し、読み出すパターンのスポットサイズが大きくなる問題がある。また、ホログラムメモリの読み書きには、異なった角度の入射光を用いる角度多重記録だけで無く、空間的に異なった場所に記録する空間分割多重記録も併用される。しかし、空間分割多重記録を多用すると、小さな記憶領域から情報を読み出す必要があるので、開口数(NA)が低下し、スポットサイズが増す問題が生じる。このように、レーザとMEMSを用いた非回転式のホログラムストレージシステムでは非常に高速な読み出しが可能になる反面、読み取る情報のスポットサイズが大きくなる欠点があった。

２．研究の目的

ホログラムメモリから読み出された情報の各々のピクセルはイメージセンサーのピクセルサイズよりも大きく、イメージセンサーの解像度を下げて読み出すことになる。このピクセルサイズは回折限界によって決まっており、これ以上小さくすることができない。そこで本研究では、ホログラムメモリから読み出されたピクセルの回折限界に達したスポット径をこれ以上小さくする試みをやめ、１つのスポットから偏光状態を読み取り、複数ビットの情報として活用する偏光ホログラムストレージシステムの開発を目指した。

３．研究の方法

本研究では 0.18μm CMOS プロセスを利用して偏光方向の検出が可能なフォトダイオードイメージセンサを試作した。フォトダイオードは P 型の基板と N-WELL の接合により作られた。フォトダイオードの上部にはメタルによりスリットが構成され、これにより偏光方向の検出が可能になる。これらの間隔を

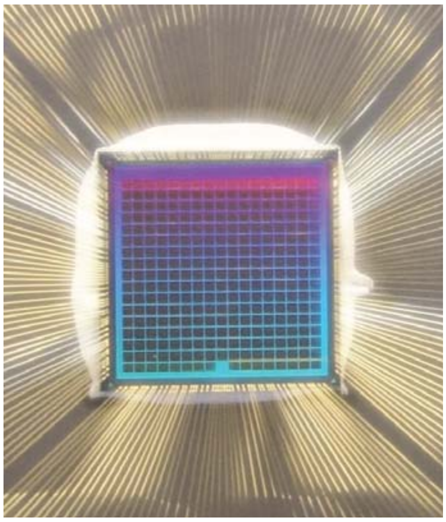

図１：偏光検出イメージセンサチップ

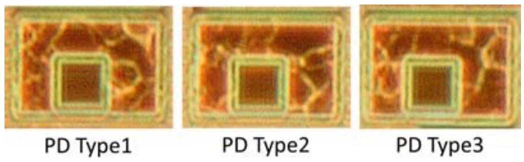

図２：フォトダイオードセルの顕微鏡写真

変えたフォトダイオードを図2に示すように３種類設計した。偏光角度の検出には垂直、水平検出の2つのフォトダイオードをセットで用いて行なう。そして、後段には偏光角検出回路が実装され、その回路において、2つのフォトダイオードの反応時間差やトータルの光強度をデジタル的に検出することになる。

４．研究成果

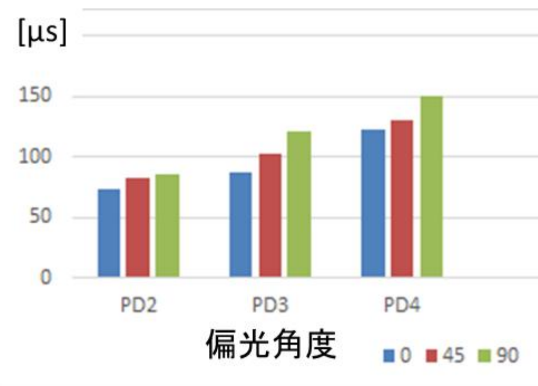

図３：偏光角度の検出試験結果

試作したフォトダイオードセルの偏光角検出の評価を行った。図３にその結果を示す。フォトダイオードが応答するように設計された偏光角度と異なる偏光方向の光を入射させると、偏光角度差に応じて読みだし時間が長くなっており、正しく角度検出ができて

いることが確認できた。上記試験では微弱光を用いており、応答速度が74μs程度から150μs かかっているが、光強度を高めることでより高速な応答、つまりホログラムメモリのより高速な読み出しが可能である。

この偏光角度検出イメージセンサーチップと MEMS とレーザアレイのインターリブ手法を用いることで従来よりも高速な読み出しができるホログラムストレージシステムが実現できることを示すことができた。

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〔図書〕（計０件）
〔産業財産権〕
○出願状況（計０件）
○取得状況（計０件）
〔その他〕ホームページ等
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