

Determination of bit patterned media noise based on island perimeter fluctuations

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We present a new media noise model for bit patterned media (BPM) that incorporates fluctuations in the shape of the magnetic islands. Conventional models use separate Gaussian distributions for the position and size of the islands. This approximation is unrealistic, since the distributions cannot be Gaussian and both distributions must be coupled. In this model, fluctuations in the island's shape are characterized by the power spectrum obtained from the variance of the perimeter of the island. Fluctuations in the island's shape cause fluctuations in the size and the center of mass of the island, which affect the shape and position of the readback pulse. A realistic media noise model is required in order to investigate the performance of error correcting codes and data detection methods via simulations [1].

In our method, the shape of an island (figure 1) is determined by its perimeter and can be described by a function of angle, $R(\theta)$, as indicated in figure 1(b). The Fourier series of the variance in $R(\theta)$ results in a power spectrum that describes the fluctuations in the island's shape. We have determined this power spectrum for a BPM using a SEM image, in which the perimeters of over 400 islands have been detected. The power spectrum is given in figure 2(a). Most of the power is contained in the first frequency components. This lets us simulate realistic island shapes (figure 2(b)) using only the first 6 components of the power spectrum.

To verify that the detected perimeters represent the magnetic geometries (i.e. the magnetic charge distributions) of the islands, we have obtained the readback pulses of the islands using a magnetic force microscope (MFM). Figure 3 shows the energies in the readback pulses of the islands against the areas of the islands. As expected, the the energy in the readback pulse is more or less proportional to the area of the islands (as indicated by the straight line), which indicates that the perimeter obtained by SEM agrees well with the magnetic geometry of the island.

We conclude that the fluctuations in the shape of the islands are sufficiently characterized by the power spectrum of the island's perimeters. Only the first 6 components of this spectrum are needed to simulate islands with realistic shapes. In simulations, the readback signal of an island can be approximated using the area and center of mass of the island, which are readily computed from the Fourier components that describe the island's perimeter. Measurements of the energy in MFM pulses confirm that the magnetic geometry of the island can be represented by its perimeter.

References

- [1] P. W. Nutter *et al.*, “Understanding sources of errors in bit-patterned media to improve read channel performance,” *IEEE Trans. Magn.*, vol. 44, no. 11 PART 2, pp. 3797–3800, 2008.

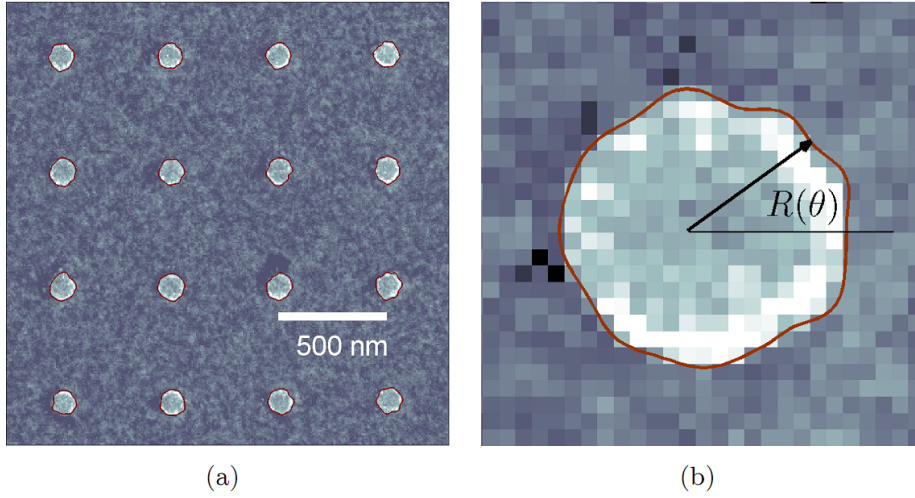


Figure 1: (a) SEM image of a bit patterned media with the detected perimeters (lines); (b) one single island in which the function that describes the perimeter, $R(\theta)$, is indicated

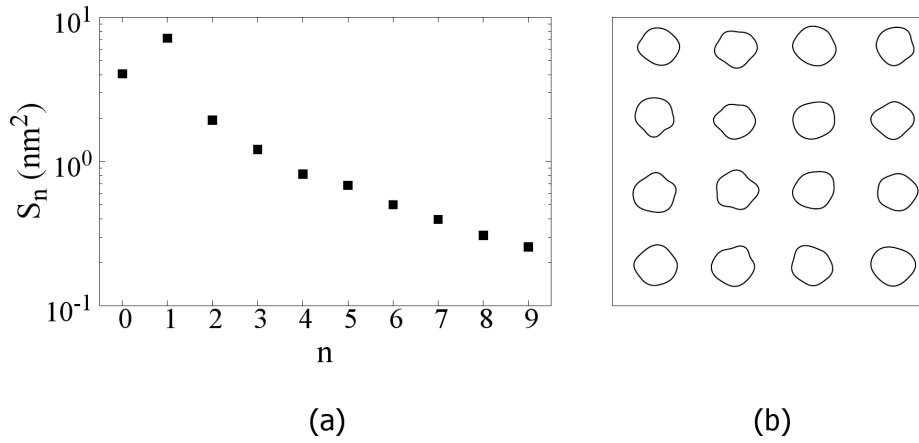


Figure 2: (a) Power spectrum corresponding to the variance in the perimeters of the islands; (b) simulated perimeters of island using the first 6 frequency components ($0 \leq n \leq 5$) of the power spectrum.

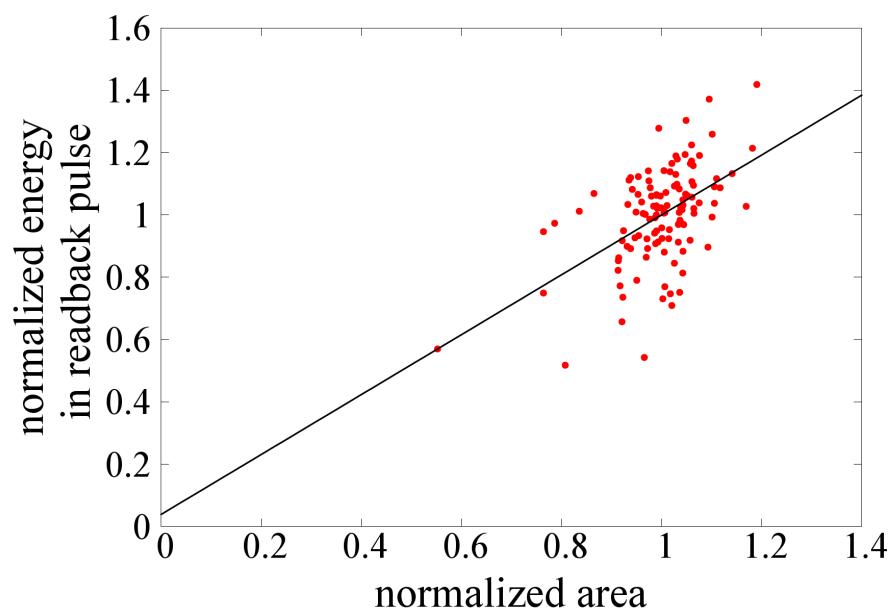


Figure 3: Normalized energy in MFM readback pulses against the normalized area of the islands. The energy of a readback pulse is computed by 2-D integration of the squared MFM output in a region around an island. The line represents a linear fit of the data points.