Apparent roadblock in the development of quantum lithography

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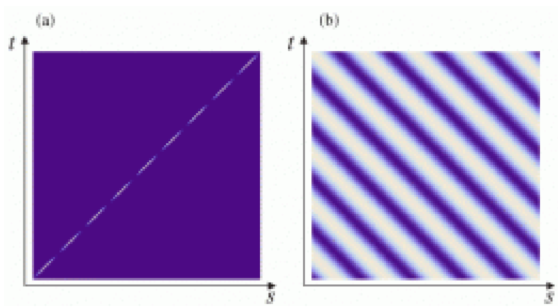

When sending two photons through a double slit they will produce an interference pattern on a detection line after the slits. Denoting the arrival position of the photons with s and t one can plot the detection probability where lighter colour indicates higher probability. If the photons are constrained to arrive at the same place the left figure applies; if they propagate independently the right figure applies. Image credit: *New J. Phys.* 13 043028 doi:10.1088/1367-2630/13/4/043028

(PhysOrg.com) -- Just when it began to appear that scientists had found a viable way around the problem of the blurring that occurs when using masks to create smaller and smaller silicon wafers for computer chips, a previous study on beam splitting optics showed that the new approach would not work, at least as it has thus far been proposed. A group of researchers explain why in a paper in *New Journal of Physics.*

Currently, the silicon wafers that make up computer chips are made by the process of lithography, whereby optics are used to create an image on a piece of wafer. To create the channels that make up the transistors, masks are used to prevent some of the photons directed towards a wafer from arriving. When the wafer is then immersed in special chemicals, the parts that were struck react differently than those that weren't, creating the channels. The problem is in the clarity of the image produced on the other side due to the use of optic lenses to focus the photons, as some degree of blurring will always occur due to the nature of lenses. As researchers try to make smaller transistors, the blurring eventually becomes a roadblock, which is why some are looking for alternatives.

One such approach is to take advantage of the unique properties of entangled photons; those wily quantum particles that for some inexplicable reason, tend to mimic the behavior of one another, without any apparent means of communication, and at a rate faster than the speed of light. Because they are correlated, the thinking went, they'd always arrive at the same place at the same time (in this case a sensor) creating a near perfect image; so if say a mask were made, in this case a simple one with just two slits in it; it would make sense that the pair of entangled photons would interfere with one another as they tend to do, as they pass through the slit, then arrive together on the other side at exactly the same place and time, which is just what you'd need if you wanted to impact the material on the other side to create your wafer the way you intended.

Unfortunately, things haven't worked out quite that way, because as it turns out, while you can expect a pair of entangled photons to do their thing simultaneously, you can't rely on them to arrive at the same target, or again in this case, the same sensor, while they are doing so; which of course is a big problem if you're trying to make a wafer where the photons have to hit their target not only at exactly the same time, but in exactly the right place or you've got nothing to show for your efforts.

Even so, researchers hoped that enough photons would arrive in the same place at the same time by chance to allow for the process to work; but this meant adding in an exposure time (waiting for enough of the photons to arrive at the same place) which as it turned out rose too rapidly as the feature size requirements went up, making the process unfeasible.

While it appears the original idea for using entangled photons for the development of quantum lithography won't work, researchers aren't giving up hope just yet; the stakes are too high. The hope now is that some other new imaginative way can be thought of to get around the problems encountered, allowing for the creation of almost unimaginably small chips.

More information: On the efficiency of quantum lithography, Christian Kothe et al 2011 *New J. Phys.* 13 043028
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Abstract
Quantum lithography promises, in principle, unlimited feature resolution, independent of wavelength. However, in the literature, at least two different theoretical descriptions of quantum lithography exist. They differ in the extent to which they predict that the photons retain spatial correlation from generation to absorption, and although both predict the same feature size, they vastly differ in predicting how efficiently a quantum lithographic pattern can be exposed. Until recently, essentially all quantum lithography experiments have been performed in such a way that it is difficult to distinguish between the two theoretical explanations. However, last year an experiment was performed that gives different outcomes for the two theories. We comment on the experiment and show that the model that fits the data unfortunately indicates that the trade-off between resolution and efficiency in quantum lithography is very unfavourable.