The aim of the disclosure~~invention~~ is thus to overcome at least one of the drawbacks of the prior art. The ~~invention~~ disclosure aims in particular to provide a simple and effective method for producing a block copolymer film for use as a nanolithography mask for the nanostructuring of a substrate, said block copolymer being capable of nanostructuring with a single period, said method allowing, in said block copolymer film, patterns of different periods to be produced, without generating defects.

[Brief description ~~of the invention~~]

To this end, in an aspect, the ~~invention~~disclosure relates to a method for nanostructuring a substrate for the preparation of a nanostructured substrate having nanostructures of different dimensions, said method comprising the following steps:

- Generating a guide surface over a substrate;
- Depositing an unassembled block copolymer layer on the guide surface, said unassembled block copolymer layer being capable of forming, after assembly, a nanostructured block copolymer in the form of nanodomains;
- Forming a crosslinked polymer layer over the unassembled block copolymer layer;
- Annealing at a temperature corresponding to the assembly temperature of the unassembled block copolymer layer;
- Removing the crosslinked polymer layer and one of the blocks of the nanostructured block copolymer so as to form patterns of a nanolithography mask;
- Etching the substrate by means of said nanolithography mask;

said method being characterized in that:

- said guide surface has areas neutral and non-neutral with respect to the unassembled block copolymer layer, at least one of said neutral or non-neutral areas of the guide surface having a first dimension;
- said crosslinked polymer layer has areas neutral and non-neutral with respect to the unassembled block copolymer layer, at least one of said non-neutral areas of the crosslinked polymer layer having a second dimension;
- said removal of one of the blocks being a removal of only part of the nanodomains of one of the blocks of the nanostructured block copolymer, in particular of only the perpendicular nanodomains of said block, so that the parallel nanodomains of at least two blocks of the nanostructured block copolymer form patterns of the nanolithography mask; and

- said first and second dimensions are different so as to generate in the nanolithography mask patterns of different dimensions and nanostructures in the nanostructured substrate of different dimensions after etching.

The method according to the ~~invention~~ disclosure allows different dimensions to be created in the nanolithography mask independently of the natural period of the block copolymer. In addition, the process allows stacks of blocks parallel to the substrate, formed at the non-neutral areas to be used as a lithography resin, and then these patterns to be transferred into the substrate at the same time as those of the block copolymer.

Advantageously, the method also allows the shape and dimensions thus described in the nanolithography mask to be varied at will. Thus, it is possible to multiply the different dimensions for a same pattern addressed on the same area of the substrate.

In addition, the non-neutral areas of the guide surface and/or of the crosslinked polymer layer are therefore of particular interest in the context of the ~~invention~~ disclosure herein. These areas from non-neutral areas consist of the two blocks of the block copolymer.

According to other optional features of the method, the latter may optionally include one or more of the following features, alone or in combination:

- the non-crosslinked block copolymer layer has a thickness at least equal to 10 nm;

- the crosslinked polymer layer has at least one non-neutral area of a dimension different from the neutral area;

- the generation of a guide surface over a substrate involves implementing chemoepitaxy or graphoepitaxy;

- the guide surface has guide resin increased thicknesses and the increased thicknesses have etching properties similar to one of the blocks of the block copolymer;

- the guide resin forming the increased thicknesses is non-neutral with respect to the block copolymer;

- the guide resin forming the increased thicknesses is neutral with respect to the block copolymer;

- etching of the guide resin is carried out in a positive mode;

- etching of the guide resin is carried out in a negative mode;

action of the first crosslinking agent in said primary areas subjected to said first stimulation and then of the second crosslinking agent in said secondary areas subjected to said second stimulation in order to obtain a crosslinked polymer layer in which the different primary and secondary crosslinked areas have an opposite affinity with respect to the blocks of the underlying block copolymer.

Other advantages and features of the ~~invention~~disclosure will appear upon reading the following description given by way of illustrative and non-limiting example, with reference to the appended figures:

[Fig 1] represents a diagram of a method for nanostructuring a substrate according to the prior art.

[Fig. 2] represents a diagram of a method for nanostructuring a substrate according to one embodiment of the invention.

[Fig. 3] represents a diagram of a method for nanostructuring a substrate according to one embodiment of the invention.

[Fig. 4] represents a diagram of a method for nanostructuring a substrate according to one embodiment of the invention.

In the following description, by "**polymer**" is meant either a copolymer (of the statistical, gradient, block, alternating type), or a homopolymer.

The term "**prepolymer**" as used refers to at least one monomer and/or dimer and/or oligomer and/or polymer having reactive groups allowing it to participate in subsequent polymerization or crosslinking and thus to incorporate several monomer units into at least one chain of the final macromolecule.

By "**polymer chain of a prepolymer**" is meant the main chain of assembly of a plurality of monomer units, with other less important chains being considered as branches of the polymer main chain.

The term "**monomer**" as used refers to a molecule that can undergo polymerization.

The term "**polymerization**" as used refers to the method of transforming a monomer or mixture of monomers into a polymer of predefined architecture (block, gradient, statistical…).

By "**copolymer**" is meant a polymer combining several different monomer units.