particle removal tool on the surface that would pick up the foreign particle but would not damage the object.

It would be convenient hereinafter to describe the invention in greater detail by reference to the accompanying drawings which illustrate preferred embodiments of the invention. The particularity of the drawings and the related description is not to be understood as superseding the generality of the broad identification of the invention as defined by the claims.

Brief Description of the Drawings

Examples of methods and apparatus for the removal of foreign particles from an object surface in accordance with the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is an overview of a cleaning apparatus comprising a particle removal system according to a preferred embodiment of the invention;

FIG. 2 is an isometric view of a tool gripper holding a particle removal tool, the particle removal tool being made to contact an external force sensor;

FIG. 3 is a graph showing an exemplary relationship between a vertical position of the particle removal tool and a force exerted by it on the external force sensor;

FIG. 4 is a side view of the particle removal system of FIG. 1, including the external force sensor of FIG. 2;

FIGs. 5A, 5B and 5C illustrate an exemplary operational sequence of the particle removal system of FIG. 4;

FIG. 6 is an isometric view of a particle removal system according to another preferred embodiment of the invention; and

FIGs. 7A and 7B illustrate an exemplary operational sequence of the particle removal system of FIG. 6.

Detailed Description of the Preferred Embodiments

FIG. 1 is an overview of a cleaning apparatus 10 comprising a particle removal system for removing a foreign particle from a surface of a fragile object according to a preferred embodiment of the invention. The cleaning apparatus 10 generally comprises an automated optical inspection device 12, a cleaning tool station 14 which contains a supply of multiple particle removal tools 16, and an optical device such as an up-look optical device 18. In the illustrated embodiment, the particle removal tools 16 are in the form of gel sticks, wherein a gel-like substance is attached to one end of a stick. Such gel-like substance is operative to attract small foreign particles and to remove them from surfaces of objects. However, the invention is not intended to be limited to particle removal tools in the form of gel sticks.

For the purpose of identifying foreign particles on inspected fragile objects, such as CMOS sensors 22 that are arranged and carried on a carrier 20, the carrier 20 is placed under the automated optical inspection device 12 for inspection of the CMOS sensors 22.

FIG. 2 is an isometric view of a tool gripper 30 holding the particle removal tool 16, the particle removal tool 16 being made to contact a force sensing device, which may be in the form of a force/pressure transducer. The force/pressure transducer may be an external force sensor 36 which is separate from both the tool gripper 30 and the particle removal tool 16. As mentioned above, the particle removal tool 16 comprises a gel stick 34 having a gel-like substance at one end thereof, and the gel stick 34 is attached to a stick holder 32. The tool gripper 30 is supported by a tool gripper arm 28, and grips onto a portion of the stick holder 32 which has been adapted for this purpose.