## CLAIMS

What is claimed is:

**1.** A touch screen for a computing device, comprising:

a housing;

a layer of light-transmissive material mounted in said housing, comprising an upper and a lower surface, wherein said upper surface is exposed for touch by one or more objects from outside of said housing;

a plurality of light emitters mounted in said housing underneath said upper surface, for emitting light beams;

a first lens assembly mounted in said housing for directing the light beams emitted by said light emitters into said layer at an angle such that the light beams, when entering said layer, remain confined to said layer by total internal reflection at said upper and lower surfaces of said layer when the light beams are not absorbed by any of the objects touching said upper surface;

a plurality of light detectors mounted in said housing underneath said upper surface, for detecting light beams and for generating outputs indicating the amounts of light detected;

a second lens assembly mounted in said housing for directing light beams at a surface of said layer towards one or more of said light detectors; and

a calculating unit, mounted in said housing and connected to said light receivers, for determining respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors,

wherein light beams in said layer are partially absorbed at said upper surface when they come into contact with any of the objects.

**2.** The touch screen of claim **1** wherein the light-transmissive material comprises glass or plastic that is transparent for infra-red light.

**3.** The touch screen of claim **1** wherein the light-transmissive material is a transmissive gel or liquid-filled sac that is transparent for infra-red light.

**4.** The touch screen of claim **1** further comprising an optically clear transfer tape to fasten said layer on said first and second lens assemblies.

**5.** The touch screen of claim **1** wherein said first lens assembly directs portions of the light beams emitted by said light emitters over said layer above said upper surface, and wherein said second lens assembly directs light beams from above said upper surface to one or more of said light detectors.

**6.** The touch screen of claim **1** wherein said first lens assembly directs the light beams emitted by said light emitters into said layer from one or more sides of said layer, and wherein said second lens assembly directs light beams emerging from or more sides of said layer to one or more of said light detectors.

**7.** The touch screen of claim **1** wherein said layer and said first and second lens assemblies comprise a single consolidated unit.

**8.** The touch screen of claim **1** wherein said light emitters are arranged along two adjacent edges of said layer, wherein said light detectors are arranged along two other adjacent edges of said layer, wherein said light emitters are shift-aligned with said light detectors, and

wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**9.** The touch screen of claim **1** wherein said light emitters and said light detectors are arranged in an alternating sequence along edges of said layer, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**10.** A touch screen for a computing device, comprising:

a housing;

a layer of light-transmissive material mounted in said housing, comprising upper and lower surfaces, wherein said upper surface is exposed for touch by one or more objects from outside of said housing;

a plurality of light emitters mounted in said housing underneath said upper surface, for emitting light beams;

a first lens assembly mounted in said housing for directing the light beams emitted by said light emitters into said layer at an angle such that the light beams, when entering said layer, remain confined to said layer by total internal reflection at said upper and lower surfaces of said layer;

a plurality of light detectors mounted in said housing underneath said upper surface, for detecting light beams and for generating outputs indicating the amounts of light detected;

a second lens assembly mounted in said housing for directing light beams at a surface of said layer towards one or more of said light detectors; and

a calculating unit, mounted in said housing and connected to said light receivers, for determining respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors,

wherein light beams in said layer are scattered back into said layer at said upper surface when they come into contact with any of the objects, so that said second lens assembly directs them to more of said light detectors than had they not been scattered.

**11.** The touch screen of claim **10** wherein the light-transmissive material comprises glass or plastic that is transparent for infra-red light.

**12.** The touch screen of claim **10** wherein the light-transmissive material is a transmissive gel or liquid-filled sac that is transparent for infra-red light.

**13.** The touch screen of claim **10** further comprising an optically clear transfer tape to fasten said layer on said first and second lens assemblies.

**14.** The touch screen of claim **10** wherein said first lens assembly directs portions of the light beams emitted by said light emitters over said layer above said upper surface, and wherein said second lens assembly directs light beams from above said upper surface to one or more of said light detectors.

**15.** The touch screen of claim **10** wherein said first lens assembly directs the light beams emitted by said light emitters into said layer from one or more sides of said layer, and wherein said second lens assembly directs light beams emerging from or more sides of said layer to one or more of said light detectors.

**16.** The touch screen of claim **10** wherein said layer and said first and second lens assemblies comprise a single consolidated unit.

**17.** The touch screen of claim **10** wherein said light emitters are arranged along two adjacent edges of said layer, wherein said light detectors are arranged along two other adjacent edges of said layer, wherein said light emitters are shift-aligned with said light detectors, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**18.** The touch screen of claim **10** wherein said light emitters and said light detectors are arranged in an alternating sequence along edges of said layer, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**19.** The touch screen of claim **10** wherein said first and second lens assemblies comprise a repeating three-sided lens pattern for directing light beams from each of said light emitters in three directions.

**20.** The touch screen of claim **19** wherein the light directed from each of said emitters in three directions is received by three of said light detectors situated along three different edges of said layer.

**21.** A light-based touch sensitive device, comprising:

a housing;

a surface encased in said housing;

a layer of elastic material above said surface;

a plurality of light pulse emitters mounted in said housing, that transmit light pulses through said layer;

a plurality of light pulse receivers mounted in said housing, that receive the light pulses transmitted through said layer; and

a calculating unit, mounted in said housing and connected to said receivers, that determines a location of a pointer that touches said layer and creates an impression in said layer, based on outputs of said receivers.

**22.** The light-based touch sensitive device of claim **21**, further comprising a haptic driver, mounted in said housing and connected to said layer and to said calculating unit, that generates haptic vibrations in said layer when the pointer creates an impression in said layer.

**23.** The light-based touch sensitive device of claim **21** wherein said layer comprises at least a portion of a flush outer surface of said housing.

**24.** The light-based touch sensitive device of claim **21** further comprising at least one light guide in said housing, that guides the light pulses from said emitters into said layer, and from said layer into said

receivers, wherein an upper surface of said layer is coplanar with an upper edge of said at least one light guide.

**25.** The light-based touch sensitive device of claim **24** wherein said at least one light guide and said layer are formed together by an overmolding process.

**26.** The light-based touch sensitive device of claim **21** further comprising at least one light guide in said housing, that guides light pulses over and across said surface through said layer, and that guides light pulses over and across said surface above said layer.

**27.** The light-based touch sensitive device of claim **21** further comprising:

an air gap between said surface and said layer; and

at least one light guide in said housing, that guides light pulses over and across said surface through said layer, and that guides light pulses over and across said surface through said air gap.

**28.** A light-based touch sensitive device comprising:

a housing;

a surface encased in said housing;

a layer of elastic material above said surface and forming an air gap between said surface and said layer;

a plurality of light pulse emitters mounted in said housing, that transmit light pulses over and across said surface through the air gap;

a plurality of light pulse receivers mounted in said housing, that receive the light pulses; and

a calculating unit, mounted in said housing and connected to said receivers, that determines a location of a pointer that touches said layer and creates an impression in said layer, based on outputs of said receivers.

**29.** The light-based touch sensitive device of claim **28** further comprising a haptic driver, mounted in said housing and connected to said layer and to said calculating unit, that generates haptic vibrations in said layer when the pointer creates an impression in said layer.

**30.** The light-based touch sensitive device of claim **28** wherein said layer comprises at least a portion of a flush outer surface of said housing.

**31.** The light-based touch sensitive device of claim **28** further comprising at least one light guide in said housing, that guides the light pulses from said emitters into the air gap, and from the air gap into said receivers, wherein an upper surface of said layer is coplanar with an upper edge of said at least one light guide.

**32.** The light-based touch sensitive system of claim **31** wherein said at least one light guide and said layer are formed together by an overmolding process.

**33.** The light-based touch sensitive device of claim **28** wherein said layer is removable.

**34.** The light-based touch sensitive device of claim **33** wherein said layer is attached to a frame that is removably attached to said housing with a snap-on motion.

**35.** The light-based touch sensitive device of claim **34** wherein said surface comprises a display, the device further comprising a non-volatile memory that stores program code providing instructions for rendering at least two user interfaces on said display; namely, a low-resolution touch-based user interface for use when said layer is attached to said housing, and a high-resolution touch-based user interface for use when said layer is detached from said housing.

**36.** The light-based touch sensitive device of claim **34** further comprising:

a radio frequency identification (RFID) chip connected to said layer; and

an RFID reader mounted in said housing, that detects attachment of said layer to said housing via said RFID chip,

wherein the program code provides instructions for presenting the low-resolution touch-based user interface when said RFID reader detects attachment of said layer to said housing.

## CLAIMS

**1.** A touch screen for a computing device, comprising:

a housing;

a layer of light-transmissive material mounted in said housing, comprising an upper and a lower surface, wherein said upper surface is exposed for touch by one or more objects from outside of said housing;

a plurality of light emitters mounted in said housing underneath said upper surface, for emitting light beams;

a first lens assembly mounted in said housing for directing the light beams emitted by said light emitters into said layer at an angle such that the light beams, when entering said layer, remain confined to said layer by total internal reflection at said upper and lower surfaces of said layer when the light beams are not absorbed by any of the objects touching said upper surface;

a plurality of light detectors mounted in said housing underneath said upper surface, for detecting light beams and for generating outputs indicating the amounts of light detected;

a second lens assembly mounted in said housing for directing light beams at a surface of said layer towards one or more of said light detectors; and

a calculating unit, mounted in said housing and connected to said light receivers, for determining respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors,

wherein light beams in said layer are partially absorbed at said upper surface when they come into contact with any of the objects.

**2.** The touch screen of claim **1** wherein the light-transmissive material comprises glass or plastic that is transparent for infra-red light.

**3.** The touch screen of claim **1** wherein the light-transmissive material is a transmissive gel or liquid-filled sac that is transparent for infra-red light.

**4.** The touch screen of claim **1** further comprising an optically clear transfer tape to fasten said layer on said first and second lens assemblies.

**5.** The touch screen of claim **1** wherein said first lens assembly directs portions of the light beams emitted by said light emitters over said layer above said upper surface, and wherein said second lens assembly directs light beams from above said upper surface to one or more of said light detectors.

**6.** The touch screen of claim **1** wherein said first lens assembly directs the light beams emitted by said light emitters into said layer from one or more sides of said layer, and wherein said second lens assembly directs light beams emerging from or more sides of said layer to one or more of said light detectors.

**7.** The touch screen of claim **1** wherein said layer and said first and second lens assemblies comprise a single consolidated unit.

**8.** The touch screen of claim **1** wherein said light emitters are arranged along two adjacent edges of said layer, wherein said light detectors are arranged along two other adjacent edges of said layer,

wherein said light emitters are shift-aligned with said light detectors, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**9.** The touch screen of claim **1** wherein said light emitters and said light detectors are arranged in an alternating sequence along edges of said layer, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**10.** A touch screen for a computing device, comprising:

a housing;

a layer of light-transmissive material mounted in said housing, comprising upper and lower surfaces, wherein said upper surface is exposed for touch by one or more objects from outside of said housing;

a plurality of light emitters mounted in said housing underneath said upper surface, for emitting light beams;

a first lens assembly mounted in said housing for directing the light beams emitted by said light emitters into said layer at an angle such that the light beams, when entering said layer, remain confined to said layer by total internal reflection at said upper and lower surfaces of said layer;

a plurality of light detectors mounted in said housing underneath said upper surface, for detecting light beams and for generating outputs indicating the amounts of light detected;

a second lens assembly mounted in said housing for directing light beams at a surface of said layer towards one or more of said light detectors; and

a calculating unit, mounted in said housing and connected to said light receivers, for determining respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors,

wherein light beams in said layer are scatteredback into said layer at said upper surface when they come into contact with any of the objects, so that said second lens assembly directs them to more of said light detectors than had they not been scattered.

**11.** The touch screen of claim **10** wherein the light-transmissive material comprises glass or plastic that is transparent for infra-red light.

**12.** The touch screen of claim **10** wherein the light-transmissive material is a transmissive gel or liquid-filled sac that is transparent for infra-red light.

**13.** The touch screen of claim **10** further comprising an optically clear transfer tape to fasten said layer on said first and second lens assemblies.

**14.** The touch screen of claim **10** wherein said first lens assembly directs portions of the light beams emitted by said light emitters over said layer above said upper surface, and wherein said second lens assembly directs light beams from above said upper surface to one or more of said light detectors.

**15.** The touch screen of claim **10** wherein said first lens assembly directs the light beams emitted by said light emitters into said layer from one or more sides of said layer, and wherein said second lens assembly directs light beams emerging from or more sides of said layer to one or more of said light detectors.

**16.** The touch screen of claim **10** wherein said layer and said first and second lens assemblies comprise a single consolidated unit.

**17.** The touch screen of claim **10** wherein said light emitters are arranged along two adjacent edges of said layer, wherein said light detectors are arranged along two other adjacent edges of said layer, wherein said light emitters are shift-aligned with said light detectors, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**18.** The touch screen of claim **10** wherein said light emitters and said light detectors are arranged in an alternating sequence along edges of said layer, and wherein said calculating unit determines respective one or more locations of the one or more objects touching said upper surface, based on outputs of said light detectors being less than outputs expected when no objects touch said upper surface.

**19.** The touch screen of claim **10** wherein said first and second lens assemblies comprise a repeating three-sided lens pattern for directing light beams from each of said light emitters in three directions.

**20.** The touch screen of claim **19** wherein the light directed from each of said emitters in three directions is received by three of said light detectors situated along three different edges of said layer.