components positioned on the composite substrate first side, including an X-ray source, a first pinhole aperture and a second pinhole aperture positioned a predetermined distance from the X-ray source; a first vacuum chamber positioned proximate to the pinhole apertures and the composite substrate first side. The X-ray scattering system includes second side small angle X-ray scattering system components positioned on a composite substrate second side, the second side small angle X-ray scattering system components including: a second vacuum chamber positioned proximate to the composite substrate second side, with the second vacuum chamber in communication with an X-ray scintillator; a charged coupled device camera in communication with the scintillator, with the scintillator comprising a scintillating layer. Presently disclosed methods further include activating the small angle X-ray scattering system to emit an X-ray beam from the X-ray source; detecting scattered X-rays on the scintillating layer; and generating imaging signals based on the scattered X-rays impacting the scintillating layer.

[0007] According to further aspects, presently disclosed methods further include sending the imaging signals of the scattered X-rays generated on the scintillating layer to a computing device; converting the imaging signals into an image; and displaying the bond line region of the composite component as a bond line region image on a small angle X-ray scattering system output.

[0008] According to another aspect, disclosed methods include detecting the presence or absence of anomalies present in the bond line region.

[0009] Further aspects disclose non-destructively detecting anomalies in a bond line of a composite material, wherein the anomalies detected in the bond line region can comprise a dimension ranging from less than 1 nm to about 1.0 mm or more.

[0009a] According to another aspect, there is provided a system for non-destructively inspecting a composite substrate, said composite substrate comprising a composite substrate first side, a composite substrate second side, and at least one adhesive material layer, said adhesive material layer interposed between the composite substrate first side and the composite substrate second side. The system comprises first side small angle X-ray scattering system components positioned on the composite substrate first side, said first side small angle X-ray scattering system components comprising: a monochromatic X-ray source; a first pinhole aperture and a second pinhole aperture positioned a predetermined distance from the monochromatic X-ray source; a first vacuum chamber positioned between the first pinhole aperture and the second pinhole aperture. The system also includes second side small angle X-ray scattering system components positioned on the composite substrate second side, said second side small angle X-ray scattering system components comprising: a second vacuum chamber positioned proximate to the composite substrate second side, said second vacuum chamber in communication with an X-ray scintillator; a charged coupled device in communication with the X-ray scintillator, said scintillator comprising a scintillating layer; imaging software in communication with the charged coupled device; a display in communication with the imaging software. The system is configured to display a microscopic two-dimensional image of the adhesive material layer.

[0010] Further aspects disclose a system for non-destructively inspecting a substrate comprising a composite material, with the system configured to detect nano-scale anomalies in a

WHAT IS CLAIMED IS:

1. A method for non-destructively inspecting a bond line in an adhesive material layer of a composite substrate, said method comprising:

positioning a small angle X-ray scattering system proximate to a composite substrate, said composite substrate comprising an adhesive material layer interposed between a composite substrate first side and a composite substrate second side, said adhesive material layer further comprising a bond line region, with said small angle X-ray scattering system comprising first side small angle X-ray scattering system components positioned on the composite substrate first side, said first side small angle X-ray scattering system components comprising:

an X-ray source;

a first pinhole aperture and a second pinhole aperture positioned a predetermined distance from the X-ray source;

a first vacuum chamber positioned proximate to the pinhole apertures and the composite substrate first side; and

with said small angle X-ray scattering system comprising second side small angle X-ray scattering system components positioned on the composite substrate second side, said second side small angle X-ray scattering system components comprising:

a second vacuum chamber positioned proximate to the composite substrate second side, said second vacuum chamber in communication with an X-ray scintillator;

a charged coupled device in communication with the X-ray scintillator, said X-ray scintillator comprising a scintillating layer;

activating the small angle X-ray scattering system to emit an X-ray beam from the X-ray source;

detecting scattered X-rays on the scintillating layer; and

generating imaging signals based on the scattered X-rays impacting the scintillating layer.

2. The method of Claim 1, further comprising:

sending an imaging signal of the scattered X-rays generated on the scintillating layer to imaging software;

generating a bond line image; and

displaying the bond line image on a display.

3. The method of Claim 2, wherein the bond line image is a two-dimensional image.

4. The method of Claim 2 or 3, further comprising:

non-destructively detecting anomalies present in the bond line.

5. A system for non-destructively inspecting a composite substrate, said composite substrate comprising a composite substrate first side, a composite substrate second side, and at least one adhesive material layer, said adhesive material layer interposed between the composite substrate first side and the composite substrate second side, said system comprising:

first side small angle X-ray scattering system components positioned on the composite substrate first side, said first side small angle X-ray scattering system components comprising:

a monochromatic X-ray source;

a first pinhole aperture and a second pinhole aperture positioned a predetermined distance from the monochromatic X-ray source;

a first vacuum chamber positioned between the first pinhole aperture and the second pinhole aperture; and

second side small angle X-ray scattering system components positioned on the composite substrate second side, said second side small angle X-ray scattering system components comprising:

a second vacuum chamber positioned proximate to the composite substrate second side, said second vacuum chamber in communication with an X-ray scintillator;

a charged coupled device in communication with the X-ray scintillator, said scintillator comprising a scintillating layer;

imaging software in communication with the charged coupled device;

a display in communication with the imaging software; and

wherein the system is configured to display a microscopic two-dimensional image of the adhesive material layer.

6. The system of Claim 5, wherein the composite substrate comprises a bond line and the system is configured to detect nano-scale anomalies in the bond line.
7. The system of Claim 5, wherein the adhesive material layer comprises a bond line and the system is configured to detect nano-scale anomalies in the bond line.
8. The system of Claim 5, wherein the adhesive material layer comprises a bond line region and the system is configured to detect nano-scale anomalies in the bond line region.

9. The system of any one of Claims 5 to 8, wherein at least a portion of the composite substrate comprises a composite material and the system is configured to detect nano-scale anomalies in the composite material.
10. The system of any one of Claims 5 to 9, wherein the adhesive material layer comprises a cured adhesive material layer and the system is configured to detect nano-scale anomalies in a bond line of the cured adhesive material layer.

11. The system of any one of Claims 5 to 9, wherein the adhesive material layer comprises an epoxy-based adhesive and the system is configured to detect nano-scale anomalies in a bond line of the epoxy-based adhesive material layer.

12. The system of any one of Claims 5 to 9, wherein the adhesive material layer comprises at least one of: an epoxy-based adhesive; a bismaleimide-based adhesive; a cyanate ester-based adhesive; an acrylate-based adhesive; a methacrylate-based adhesive; a polyurethane-based adhesive; a silicone-based adhesive; or combinations thereof; and the system is configured to detect nano-scale anomalies in a bond line of the adhesive material layer.

13. The system of any one of Claims 5 to 12, wherein the system is configured to detect nano-scale anomalies in a bond line of an epoxy-based adhesive material layer.

14. The system of any one of Claims 5 to 13, wherein the system is configured to detect nano-scale anomalies in a bond line of an epoxy-based composite substrate.

15. The system of any one of Claims 5 to 14, wherein a stationary object comprises the composite substrate, and the system is configured to detect nano-scale anomalies in a bond line in the stationary object.
16. The system of any one of Claims 5 to 14, wherein a primary structure of a vehicle comprises the composite substrate, and the system is configured to detect nano-scale anomalies in a bond line in the primary structure of the vehicle.
17. The system of any one of Claims 5 to 14, wherein the composite substrate comprises a primary structure of an aircraft, and the system is configured to detect nano-scale anomalies in a bond line in the primary structure of the aircraft.
18. The system of Claim 15, wherein the stationary object is a pipe, and the system is configured to detect nano-scale anomalies in a bond line in the pipe.
19. The system of Claim 16, wherein the vehicle is selected from the group consisting of:

a manned spacecraft; and unmanned spacecraft; a manned aircraft; an unmanned aircraft; a manned hovercraft; an unmanned hovercraft, a manned rotorcraft; an unmanned rotorcraft; a manned terrestrial vehicle; an unmanned terrestrial vehicle; a manned surface watercraft; an unmanned surface watercraft; a sub-surface watercraft; an unmanned sub-surface watercraft, a manned satellite; an unmanned satellite, and combinations thereof, and the system is configured to detect nano-scale anomalies in a bond line in the vehicle.